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RESEARCH PAPER

INFLUNCE OF CULTIVARS, PLANT GEOMETRY, HUMIC ACID AND THEIR INTERACTIONS ON GROWTH AND YIELD OF NIGER (Guizotia abyssinicia Cass.) CROP

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A B S T R A C T:

A field experiment was undertaken during the spring growing season of 2020 at the experimental farm Qalamurtga- Erbil with GPS reading of (Latitude 36^{o} 20′ 53.81" N, altitude 44^{o}06′ 20.76 ") to study the effect of three Niger cultivars (Bengalnuglue, Karal and Animax), two plant density (45 and 60cm) between rows and three levels of humic acid (0 ,350 and 700) mg L^{-1} on Niger (*Guizotia abyssinicia* Cass.) growth, yield and its component and yield using factorial RCBD with three replicates. The results indicated to recording the highest seed yield values (547.46 ,549.04 and 664.74) kg ha^{-1} for Animax cultivar, 45cm distance between rows and spraying of 700mg L^{-1} humic acid respectively. The combination between Animax cultivar – 45cm distance between rows -700mg L^{-1} humic acid ($C_3 \times G_1 \times HA_2$) recorded the highest value for seed yield kg ha^{-1} which was (759.06) kg ha^{-1}.

KEY WORDS: Niger cultivars, Row density, Humic acid, Growth and Yield.
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1.INTRODUCTION :

Niger crop (*Guizotia abyssinica* Cass.) is a member of the Asteraceae family. It is a valuable oilseed crops that also has therapeutic qualities which is mostly cultivated in India and Ethiopia. It is also known by other names, including noog , nyger, nyjer khursani , and others Niger crop provides about 3% of Indian oilseed output and 50 % of Ethiopian oilseed production (Adarsh et al., 2014) . Niger seeds contain 40 % oil and 20% protein, the edible oil extracted from Niger seeds have a “nutty flavor and a nice odor” (Dakanwale, 2018).

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It is primarily used in food preparation, manufacturing of cosmetics and soaps, painting of buildings, and lubrication of machinery. Niger seed is exported as bird feed, generating revenue for the nation and generating foreign currency (Kivadasannavar, 2005). Despite the fact that it is an oil seed crop, the potential of Niger has not been fully explored owing to the poor producing capacity of its cultivars and sensitivity to a variety of abiotic and biotic stressors (Ghane et al., 2012).
However, although a crop's yield is determined by its cultivars, its environment plays a significant influence in determining the potential yield of a cultivars within its genetic limit.
One of the most important objectives in agriculture is to determine the optimal plant density for producing the required yield. (Purcell et al., 2002).It was also shown that increasing density resulted in increased seed output,

Furthermore, all of these factors have an impact on crop development, seed production, and quality characteristics (Ukale, 2014).

Humic acid is one of the most important components of the bio liquid complex, and it is abundant in soil, it is not a fertilizer, although it may be used in conjunction with fertilizer to enhance its effectiveness. It has a wide variety of positive impacts on agricultural production as a result of its molecular structure, it aids in the transfer of micronutrients from the soil to the plant, improves water retention, increases seed germination rates, improves water, air, and root penetration, (Mackowiak et al., 2001).

Since this crop was cultivated for the first time in Erbil governorate IKR for this reason some factors were selected in this study such as cultivars, the plant geometry (distance between rows), humic acid and their interaction in order to study the effect of cultivars, plant geometry, humic acid and growth, yield and their components.

MATERIALS AND METHODS:

Afield experiment was conducted in Erbil governorate at the experimental farm Qalamurtga with GPS reading of (Latitude 36^{o} 20′ 53.81" N, altitude 44^{o}06′ 20.76 ") Fig (1) during the Spring growing season of (2020).

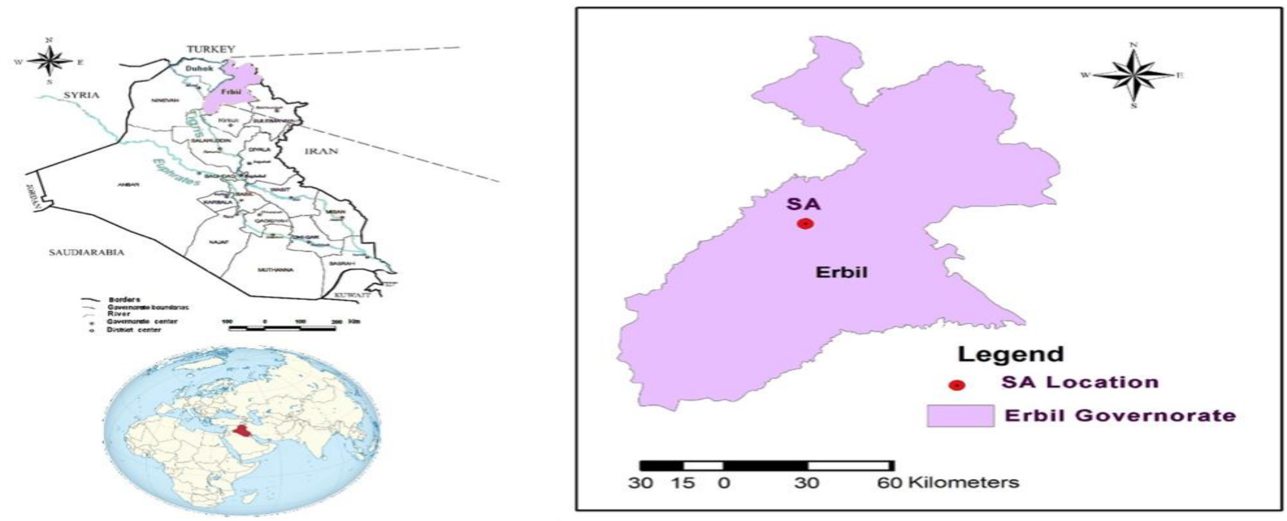


Figure 1 The location map of the field experiment

To investigates the effect of row spacing and levels of humic acid spraying and their combinations on the phonological traits, yield and its components of three Niger cultivars. The representative soil sample were taken from various locations of the field at (0-30cm) depth after tillage process, these samples were air dried, sieved using 2 mm sieve, then packed and stored for soil analysis, table (1).

Table 1: Some selected physical and chemical properties of the soil at the experimental site.

Soil Property		Unit	Average value
Particle size distributi	Sand	g kg^{-1}	14.50
	Silt		30.09
	Clay		54.06

on	Textural Name		clayey
pH			7.64
Ec		dSm^{-1}	0.295
Organic Matter		$g\ kg^{-1}$	5.00
Calcium carbonate equivalent			180
Major nutrient content	Total Nitrogen	%	1.30
	Available Phosphorus	$mg\ kg^{-1}$	4.70
	Available K		156

The field was divided into three blocks; each block was divided into 18 plots. The plot dimensions were (2m x 1m) with five rows per plot in case of first geometry(45cm) and four rows in the second geometry (60 cm) between rows while 20 cm distance between plants to achieve (100.000) and (125.000) plants per hectare. The distance between experimental units within the block was 0.5 m, while the space between blocks was 1m. A factorial experiment was done utilizing randomized complete block design (RCBD) with three replicates, the studied factors were:

The first factor included three Indian Niger cultivars which imported from research center of Suleimani governorate, which were:

C_1 = Bengalnuglue cultivar. C_2 = Karal cultivar. C_3 = Animax cultivar.

The second factor included two plant geometry:

G_1 = 45 cm distance between rows which included 25 plants plot $^{-1}$

G_2= 60 cm distance between rows which included 20 plants plot $^{-1}$.

The third factor represented humic acid application encompassed the following level which k7applied in split of 10 days' interval.

HA_0 = Control, or spraying only distilled water. HA_1 = 350 mg L^{-1}. HA_2 = 700 mg L^{-1}.

The experiment was done under rain fed condition and irrigated according to crop requirement, weed control was done by hand method, the amount of rainfall and temperature were shown in Fig. 2:

Table 2: Metrological data for Qalamurtga field during growing season of (2020):

Months	Temperature in (^{o}C)		Rainfall mm month^{-1}	Humidity %	Sunshine hr (s)/day
	Max	Min			
January	12.50	5.60	101.4	80.9	4.3
February	13.20	6.50	55.7	78.9	5.1
March	11.60	19.40	126.5	73.8	6.4
April	24.00	13.40	43.2	66.7	5.1
May	32.30	19.50	14.3	55.6	10.6
June	37.70	30.70	1.5	37.0	12.6

July	42.70	30.00	0.1	29.5	11.7

Sowing was done in tood cells on 11/3/2020 to prepare seedling while transplanting was done on 9/4/2020. Foliar application of 100 ppm Nano NPK (20.20.20) was added to each plot after the placement of seedling, harvesting done from (14 /7/2020) to (27/7/2020) as the plant is indeterminate plant and its fruit causes shattering.

Niger Trait Determination:

1-Vegetative Growth characteristics:

Plant height (cm), number of primary and secondary branches plant^{-1}, leaf Area (cm^2 plant^{-1}) measured by types of image (J) software (Easlon and Bloom, 2014) and (Mohammed and Amin, 2019).

Leaf Area Index: The leaf area index calculation was based by an App for measuring grapevine canopy architecture (Viticanopy application) for 15 leaves selected randomly

$$\textbf{Leaf area index} = \frac{\text{Plant total leaf area}}{\text{Average land area occupied by plant}} \ldots\ldots\ldots\ldots \ \mathbf{1}$$

Chlorophyll Content (SPAD) Index:

Leaf chlorophyll contents were measured using Minolta SPAD chlorophyll meter as a hand-held device has been used for recording an index of chlorophyll concentration in leaves before blooming (Thakur et al., 2013).

Yield and Yield Components:

Number of Flowers Plant$^{-1.}$ Number of Capita (head) Plant$^{-1.}$ Number of Seed Capita^{-1}

For determining the number of seeds capita^{-1} 50 capita(head) were taken randomly from each experimental unit of the selected plants, swathed by hand and then mean number of seeds per capita was calculated**.**

Weight of 1000 Seeds (g):

Seed Yield (kg ha^{-1}):

The plant seeds were collected from each plot, grind, sieved and then the seed weighted. The weight was converted to (kg ha^{-1}).

Biological Yield (kg ha^{-1}):

Plant harvested from each experimental unit, weighted, then converted to (kg ha^{-1}).

Harvest Index (HI) (%) :Calculated according to following formula (Ion et al., 2015).

$$\text{HI} = \frac{(\textbf{Seed yield})}{(\textbf{Biological yield})} \times \mathbf{100} \ldots\ldots\ldots\ldots \ \mathbf{2}$$

Statistical Data Analysis

Results in these experiments were analyzed statistically using General Linear Model (GLM) according to the analysis of variance (ANOVA) approach for Factorial randomized complete block design (RCBD) using SPSS program version (26) Duncan's multiple range test was used to determine the difference between treatment means at a significance level of 5%. (Duncan, 1955) . Eventually the charts were drawn using excel software package.

Results and Discussion

Results and Discussion

Plant Height (cm):

Table (3) shows the significant effect of cultivars ,plant geometry and humic acid application on plant height, the highest value (108.57) cm was recorded from Animax cultivar, whilst, the lowest value (91.33) cm was noted from Benglanuglue cultivar, this similar results were obtained by (Omidi and Sharifmogadas, 2010), and (Gholamreza et al., 2011) they revealed that there are differences between cultivars .

The plant height increased significantly with 60 cm than 45 cm spacing with the values of (105.65 and 91.26) cm respectively. Table (3) explains increase in concentration of sprayed humic acid caused significant increase in plant height 34.66% in comparing with control treatments, this result are in agreement with those obtained by (Abdel-Mawgoud et al., 2007) and (ÖZyazici, 2020).

The interaction between cultivars and row spacing (C × G) were affected significantly at $P \leq 0.05$ on plant height, the highest value (116.00) cm was observed in (Animax x G_2), while the lowest value (81.14) cm was recorded from (Benglanuglue x G_1).

Significant effect of the interaction between cultivars and humic acids (C × HA) was obtained the highest plant height (129.96) cm was observed from (C_3 x HA_2), the lowest value (74.51) cm was observed from (C_1 x HA_0) , similar result was found by (Gürsoy et al., 2016).

It is clear from the data given in Table (3) that the plant height affected significantly by the interaction between plant geometry and humic acid (G × HA). the highest value (123.54) cm was recorded from (G_2 × HA_2). Whereas the lowest height (78.31) cm was recorded from (G_1 × HA_0). This impact could be connected to the role of humic acid in soils and plants., which can play a very crucial role in soil conditioning and plant growth. The interaction between $C_3xG_2xHA_2$ recorded the highest plant height with value 138 66cm.

Table 3: Effect of cultivar, plant geometry, humic acid and their interactions on plant height

Cultivar (C)	Humic acid HA	Geometry (G)		Means of	Means of		
		45cm	60cm	Cultivar	Humic acid	C*HA	
Benglanuglue	0	65.33^{e}	83.70^{de}	91.33^{b}	84.85^{c}	74.51^{c}	
	350	83.16^{de}	95.20^{b-e}			89.18^{bc}	
	700	94.93^{b-e}	125.66^{ab}			110.3^{ab}	
Karal	0	84.66^{de}	96.26^{b-e}	95.47^{b}	96.26^{b}	90.46^{bc}	
	350	91.20^{cde}	95.63^{b-e}			93.41^{bc}	
	700	98.76^{bcd}	106.3^{bcd}			102.53^{b}	
Animax	0	84.93^{de}	94.20^{b-e}	108.57^{a}	114.26^{a}	89.56^{bc}	
	350	97.13^{b-e}	115.23^{a-d}			106.18^{b}	
	700	121.26^{abc}	138.66^{a}			129.96^{a}	
Means of	G	91.26^{b}	105.65^{a}				
	C *G	81.14^{b}	101.52^{ab}	91.54^{b}	99.40^{ab}	101.11^{ab}	116.00^{a}
	G*HA	78.31^{c}	90.50^{bc}	104.98^{b}	91.38^{bc}	102.02^{b}	123.54^{a}

Mean values followed by the same letter are not significantly diff erent at the 5% probability level according to Duncan test.

No. of primary branches plant^{-1}:

Table (4) shows that Animax Cultivar produced statistically the highest number of primary branches (17.43) followed in order by Benglanuglue and Karal cultivars. The lowest number of primary branches (15.45) was produced in Karal cultivar. Variation in number of primary branches plant of cultivars might due to their differences in genetic properties.

The number of primary branches plant^{-1} was significantly superior in G2 spacing. Comparative decrease in number of branches at closer spacing may be due to more competition for light, space and nutrients among the plants, which resulted in vertical growth of the plant rather than horizontal growth. These results are in conformity with the findings of (Kivadasannavar, 2005) and (Ukale, 2014)

The presented results in the Table (4) indicated in significant effect of spraying humic acid on number of primary branches per plant. The highest number of primary branches plant^{-1} (18.84) was obtained from spraying Niger plants by humic acid at (700 mg L^{-1}) while the lowest number (13.57) was noted from control (HA_0).

The interactions between (C × G) affected significantly on number of primary branches per plant, the highest and lowest values. (18.19 and 14.20) were recorded from interaction treatments of (C_3G_2 and C_1G_1) respectively. These results agree with the previous findings of (Pourhadian and Khajehpour, 2009).

The interaction between (C*HA) affected significantly on no of primary branches, the highest and lowest values (20.18 and 11.90) branches plant^{-1} were recorded from the

interaction treatments (C_1*HA_2) and (C_1*HA_0), respectively.
The interaction between G x HA was significantly affected on primary branch, the highest and lowest value (19.66 and 11.88) branch plant $^{-1}$ was recorded for G_2 xHA_2 respectively.

Furthermore, the interactions among the three studied factors cultivar, plant geometry and humic acid (C× G ×HA) had significant effect on number of primary branches plant^{-1}. the highest and lowest no of primary branch (21.50 and 9.00). were obtained from interaction treatments of (C_1* G_2* HA_2) and (C_1* G_1* HA_0) respectively.

Table 4: Effect of cultivar, plant geometry, humic acid and their interactions on Number of Primary Branches Plant^{-1}:

Cultivar (C)	Humic acid HA	Geometry (G)		Means of			
		45cm	60cm	Cultivar	Humic acid	C*HA	
Benglanuglue	0	9.00 ^{i}	14.80 fg	16.41 ^{b}	13.57^{c}	11.90 ^{f}	
	350	14.73 ^{fg}	19.60 ^{ab}			17.16 ^{bcd}	
	700	18.86 ^{bcd}	21.50 ^{a}			20.18 ^{a}	
Karal	0	12.40 ^{h}	14.73 ^{fg}	15.45 ^{c}	16.89 ^{b}	13.56 ^{ef}	
	350	14.23 ^{gh}	16.86 $^{c-f}$			15.55 ^{cde}	
	700	16.10 ^{fg}	18.40 $^{b-e}$			17.25 ^{bcd}	
Animax	0	14.26 ^{gh}	16.26 ^{efg}	17.43 ^{a}	18.84 ^{a}	15.26 ^{de}	
	350	16.66 ^{def}	19.23 ^{b}			17.95 ^{abc}	
	700	19.10 ^{bc}	19.19^{b}			19.09 ^{ab}	
Mean of	G	15.04 ^{b}	17.83 ^{a}				
	C *G	14.20 ^{b}	18.63 ^{a}	14.24 ^{b}	16.66 ^{ab}	16.67^{ab}	18.19 ^{a}
	G*HA	11.88 ^{c}	15.21 ^{b}	18.02 ^{a}	15.26 ^{b}	18.56^{a}	19.66^{a}

Mean values followed by the same letter are not significantly different at the 5% probability level according to Duncan test

No. of secondary branches plant^{-1}:

Table (5) explains that there was a significant difference between Niger cultivars. The highest number of secondary branch plant^{-1} was obtained from Animax cultivars (15.63). On the other hand, the lowest values (12.47) was obtained from the Benglanuglue cultivar these results agree with (Shaikh 2019).
The effect of different plant geometry on the number of lateral branches was significant at $P \leq 0.05$, table (5). It shows that (G_2) recorded larger number compared with plant geometry (G_1). which recorded (15.83) and (13.27) branches plant^{-1} respectively.
Spraying HA affected significantly on number of secondary branches, the lowest number of (11.68) branches plant^{-1} was recorded from control treatment , while the highest value (17.60) was recorded from treatment (HA_2) (Ayas and Gulser, 2005) obtained the same results

Regarding the effect of interaction treatment between cultivar and plant geometry (C ×G) on the number of secondary branches plant^{-1}, it showed significant differences. Maximum values and minimum (17.55and 11.64) branches plant^{-1} were produced by(C_2 × G_2) and (C_1×G_1)respectively ,this result was in agreement with (Salehian et al., 2002) and (Ouzouni et al., 2007).
The same table indicates to the interaction treatments (C x HA) which had a significant effect on the same trait. The highest number of secondary branches plant^{-1} (19.11) was recorded from interaction treatment of (C_2 x HA_2) while the lowest value (8.51) was obtained from (C_1x HA_0).
The statistical analysis showed the significant interaction effect of plant density and humic acid application (G x HA) on the number of secondary branches as shown in table (5). The highest number of secondary branches plant^{-1} (19.20) was produced from thinner density of 60 cm with high

concentration of humic acid (G_2 x AH_2), While the lowest value (10.96) was recorded by denser planting of 45 cm and control treatments (G_1 ×HA_0).

Table 5: Effect of cultivar, plant geometry, humic acid and their interactions on number of secondary branches plant^{-1}:

Cultivar (C)	Humic acid HA	Geometry (G) 45cm	Geometry (G) 60cm	Means of Cultivar	Means of Humic acid	Means of C*HA	
Benglanuglue	0	8.20^{f}	8.83^{f}	12.47^{b}	11.68^{c}	8.51^{d}	
	350	11.20^{ef}	13.30^{de}			12.25^{c}	
	700	15.53^{bcd}	17.80^{bc}			16.66^{ab}	
Karal	0	11.06^{ef}	13.10^{de}	15.55^{a}	14.36^{b}	12.08^{c}	
	350	13.00^{de}	17.90^{bc}			15.45^{b}	
	700	16.56^{bcd}	21.66^{a}			19.11^{a}	
Animax	0	13.63^{de}	15.30^{bcd}	15.63^{a}	17.60^{a}	14.46^{bc}	
	350	14.33^{cde}	16.46^{bcd}			15.40^{b}	
	700	15.93^{bcd}	18.13^{b}			17.03^{ab}	
Mean of	G	13.27^{b}	15.83^{a}				
	C *G	11.64^{c}	13.31^{bc}	13.54^{bc}	17.55^{a}	14.63^{abc}	16.63^{ab}
	G*HA	10.96^{c}	12.84^{c}	16.01^{b}	12.41^{c}	15.88^{b}	19.20^{a}

Mean values followed by the same letter are not significantly different at the 5% probability level according to Duncan test

The interaction among the three studied factors (C x G x HA) on the number of secondary branches plant^{-1}. The highest and lowest corresponding values (21.66 and 8.20) were recorded from interaction treatments of (C_2 x G_2 x HA_2) and (C_1 x G_1 x HA_0) respectively.

leaf area (cm^2):

The data in Table (6) explains the significant effect of cultivars, geometry and humic acid on leaf area, the highest values (57.26,58.69 and 60.58) cm^2 were recorded from C_1, G_2 and HA_2 respectively. Similar results were obtained by (Getinet and Sharma, 1996) they revealed that there are differences in leaf area between Niger cultivars in there comparison study additionally , (Kumar and Kubsad, 2014), and (Sandeepand and Kubsad, 2017) record highest leaf area in 60 row spacing.

The interaction between cultivars and plant geometry also affected significantly on leaf area the highest and lowest values (66.70 and38.18) cm^2 attained from the interaction treatment of (C_1 * G_2) and (C_2 * G_1) respectively. This finding is in the similar of the study conducted (Sandeepand and Kubsad, 2017) when they found that the largest leaf area is obtained when the distance between row is 60 cm.

Leaf area was significantly affected by the interaction between cultivar and spraying of humic acid application (C × HA). The (C_1 × HA_2) treatment showed the maximum leaf area of (69.36) cm^2 whereas the minimum leaf area of (37.50) cm^2 was recorded from the (C_2 × HA_0) treatment. This result is in agreement with (Khalaf and Assal, 2021). They resulted that 6ml.litre^{-1} obtained the highest leaf area 0.52 cm^2. plant^{-1} followed by 4ml.litre^{-1}.

Furthermore, the impact of interaction treatments between plant geometry and humic acid (G × HA) was significant for the trait of leaf area. The (G_2 × HA_2) performed the best result which was (68.95) cm^2 while the smallest leaf area of (35.63) cm^2 was recorded from the (G_1 × HA_0) treatment. This result shows that HA_2 humic acid effects the leaf area at G_2 more than other treatments.

The interaction among the studied factors of cultivar, plant geometry, and humic acid (C × G × HA) showed a positive effect on area of leaf. The maximum leaf area of (82.29) cm^2 was recorded from the interaction of (C_1 × G_2 × HA_2), whereas the minimum leaf area of (27.13) cm^2 was obtained from the interaction of (C_2 × G_1 × HA_0).

Table 6: Effect of cultivar, plant geometry, humic acid and their interactions on Leaf Area (cm^2)

Cultivar (C)	Humic acid HA	Geometry (G)		Means of			
		45cm	60cm	Cultivar	Humic acid	C*HA	
Benglanuglue	0	37.17^{g}	52.62^{cde}	57.26^{a}	42.71^{c}	44.89^{de}	
	350	49.88^{c-f}	65.18^{b}			57.53^{bc}	
	700	56.42^{bcd}	82.29^{a}			69.36^{a}	
Karal	0	27.13^{h}	47.87^{def}	45.25^{c}	51.99^{b}	37.50^{e}	
	350	40.55^{fg}	49.91^{c-f}			45.23^{de}	
	700	46.87^{ef}	59.16^{bc}			53.02^{bcd}	
Animax	0	42.61^{fg}	48.86^{def}	52.77^{b}	60.58^{a}	45.73^{cde}	
	350	49.51^{def}	56.93^{bcd}			53.22^{bcd}	
	700	53.32^{cde}	65.39^{b}			59.36^{ab}	
Mean of	G	44.83^{b}	58.69^{a}				
	C *G	47.82^{b}	66.70^{a}	38.18^{c}	52.31^{b}	48.48^{b}	57.06^{b}
	G*HA	35.63^{a}	49.38^{b}	49.96^{b}	49.78^{b}	57.34^{b}	68.95^{a}

Mean values followed by the same letter are not significantly different at the 5% probability level according to Duncan test

Leaf area index (LAI):

It is clear from table (7) that the leaf area index affected significantly by Niger cultivars the highest and lowest value (0.81 and 0.63) Animax and Karal cultivars, this may be due to genetic variation between the Niger cultivars.

Additionally, leaf area index affected significantly by plant geometry(G), the highest value was obtained in G_1(0.78), whiles the lowest value (0.66) was recorded in 60 cm, this finding revealed that the LAI increased as the plant density decreased due to more leaf area occupied per unit ground area for maximum light interception and photosynthesis. similar result was reported by (Meti, 2002) and (Ukale, 2014) when they noticed that LAI is negatively associated with the planting density .

The statistical analysis of the data indicated that the interaction treatment between cultivar and plant geometry (C × G) had a substantial impact on the Niger leaf area index. The largest leaf area index of (0.94) cm^2 was attained from the (C_3 × G_1) interaction treatment, and the minimum leaf area index of (0.60) cm^2 was recorded from the (C_2 × G_2) treatment. The (C_3 × HA_1) treatment showed the maximum leaf area index of (0.92) cm^2 whereas the lowest value (0.57) cm^2 was recorded from (C_2 × HA_1) interaction treatment. In addition, the influence of interaction treatment between plant geometry and humic acid (G × HA) was significant for this trait. The (G_1 × HA_2) performs the best result which was (0.88) and (0.46) was recorded from (G_2 × HA_2).

Table (7) shows the interaction treatment effect of the studied factors (C ×G × HA) on the leaf area index. The highest value of (1.01) was obtained from the treatment combination of (C_3 ×G_1 × HA_1), while the lowest value of (0.34) cm^2 was recorded from the combination treatment of (C_2 ×G_2 × HA_2), this may be due to single factors which affected leaf area as mentioned in table (7) and is on pair with in (Sandeepand and kubsad, 2017). These results clearly indicated that increased photosynthetic area of the crop that might have resulted in increased leaf area which in turn resulted in increased growth and yield parameters.

Table 7: Effect of cultivar, plant geometry, humic acid and their interaction on Leaf Area Index (cm^2):

Cultivar (C)	Humic acid HA	Geometry (G)		Means of			
		45cm	60cm	Cultivar	Humic acid	C*HA	
Benglanuglue	0	0.64^{abc}	0.66^{a-e}	0.71^{ab}	0.72^{a}	0.65^{ab}	
	350	0.80^{abc}	0.80^{abc}			0.80^{ab}	
	700	0.74^{a-d}	0.62^{b-e}			0.68^{ab}	
Karal	0	0.55^{cde}	0.81^{abc}	0.63^{b}	0.76^{a}	0.68^{ab}	
	350	0.51^{cde}	0.64^{a-e}			0.57^{b}	
	700	0.93^{ab}	0.34^{e}			0.63^{ab}	
Animax	0	0.84^{abc}	0.80^{a-e}	0.81^{a}	0.67^{a}	0.82^{ab}	
	350	1.01^{a}	0.82^{abc}			0.92^{a}	
	700	0.98^{ab}	0.43^{d-e}			0.70^{ab}	
Mean of	G	0.78^{a}	0.66^{b}				
	C *G	0.73^{a}	0.69^{b}	0.66^{b}	0.60^{b}	0.94^{a}	0.68^{b}
	G*HA	0.68^{a}	0.77^{a}	0.88^{a}	0.76^{a}	0.75^{a}	0.46^{b}

Chlorophyll content (SPAD):

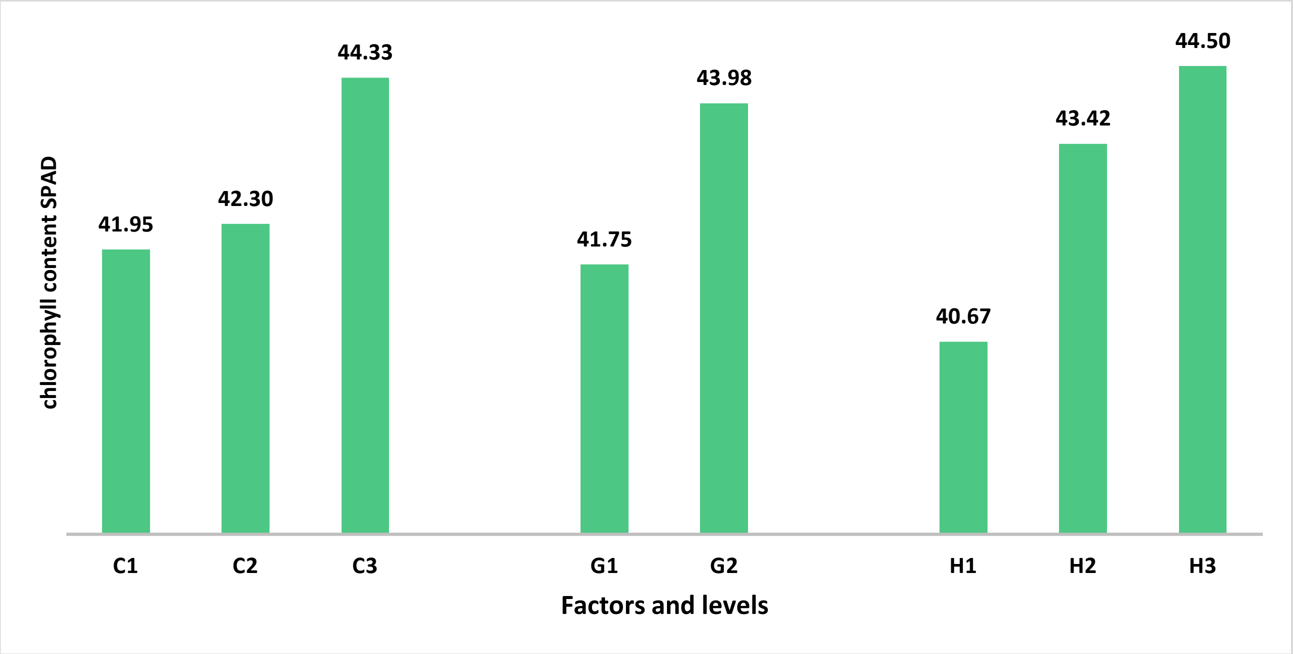
The data in fig (2) portrays the SPAD value as an index of chlorophyll content as influenced by Niger cultivars, plant geometry and humic acid spraying and their interactions, each value represents mean value of SPAD.

The C_3 cultivar, 60 cm between rows responded better to the 3rd levels of humic acid, the highest value was (44.33, 43.98 and 44.50) for SPAD reading while the lowest readings (41.95, 41.75 and 40.67) was obtained for C_1 ,45 cm between rows and no humic acid spraying respectively.

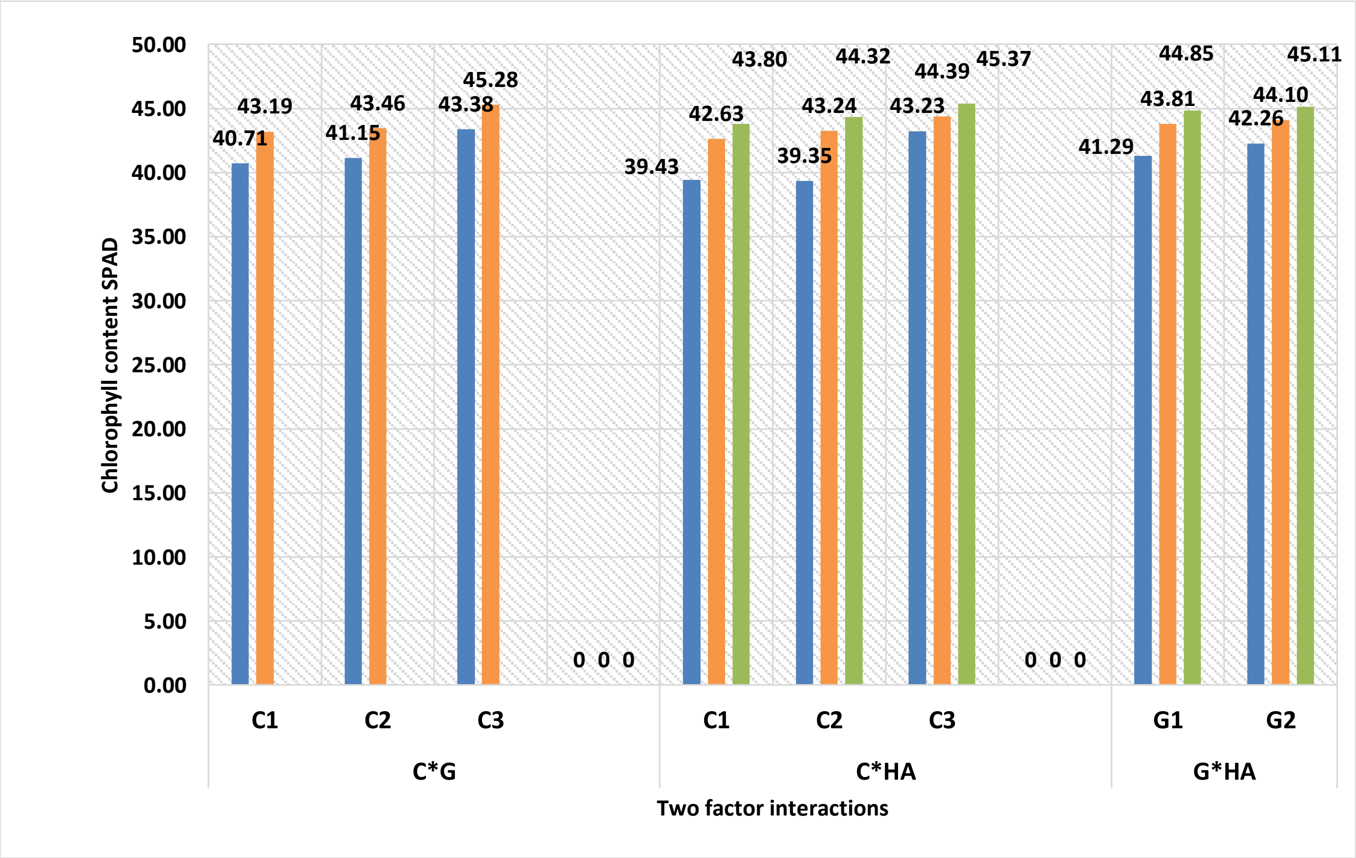
This may be due to humic acid which amplified permeability of cell membrane and, thereby, facilitated the entrance of potassium (K) into the cell which accordingly raises the pressure inside the cell and cell division. On the other hand, increasing energy inside the cells would lead to chlorophyll production 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 (Giasuddin et al., 2007).

As per finding, a sustainable difference was found between the interaction treatments for producing SPAD values, the highest and lowest values (45.37and 39.35), (41.29, 45.11) and (40.71 and, 45.28) were recorded in the interaction between (C_3HA_2 and C_1HA_0), (G_1HA_0 and G_2HA_2) and (C_1G_1 and C_3G_2) respectively

Overall, the leaf chlorophyll content can be observed that, it ranged from 37.47 to 45.99 units being the lowest with ($C_1G_1HA_0$) and the highest with ($C_3G_2HA_2$) these results were confirmed by the finding obtained by (Meganid et al., 2015),who revealed the most profound influence of foliar application of third levels of humic acid on leaf chlorophyll content comparing with control treatment.



chlorophyll content SPAD
41.95
42.30
44.33
41.75
43.98
40.67
43.42
44.50
C1
C2
C3
G1
G2
H1
H2
H3
Factors and levels



Chlorophyll content SPAD
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
40.71
43.19
41.15
43.46
43.38
45.28
0 0 0
39.43
42.63
43.80
39.35
43.24
44.32
43.23
44.39
45.37
0 0 0
41.29
43.81
44.85
42.26
44.10
45.11
C1
C2
C3
C*G
C1
C2
C3
C*HA
G1
G2
G*HA
Two factor interactions

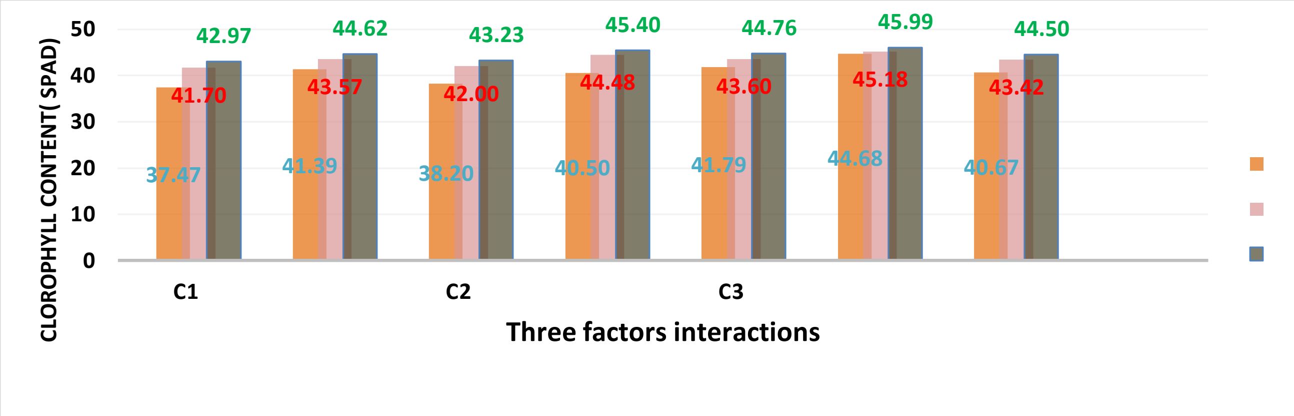


Fig (3) SPAD reading as affected by studied factors and all possible interactions between them

Yield and yield component:

1-Number of capita plant^{-1}:

The number of heads per plant is one of the important factors of Niger crop yield, data in table (8) explain that the number of capita plant^{-1} was significantly affected by Niger cultivars. The highest number of capita plant $^{-1}$ (24.95) was recorded from (C_3) cultivar while the lowest value (21.70) was recorded from C_2, this may be due to genetic factors.

The row spacing 60 cm (G_2) produced maximum number of capita per plant (25.08) and significantly superior over 45 cm between the rows. This may be due Similar trend was observed by (Kannababu et al., 1998).

The results in the same table shows that humic acid clearly increased the number of capita per plant. the number of capita per plant increased up to 18.20 and 31.98 % comparing with control respectively.

This may be due to that humic acid increase the biomass production and the secondary branches by increasing the nitrogen content and survival rate of leaves that resulted in enhancing the number of capita per plant. The similar result, was found by (Safaei et al., 2014) and (Tadayyon et al., 2017)

The interaction between cultivars and geometry had significant influence on number of capita plant $^{-1}$. The highest and lowest values (26.58 and 19.97) were recorded from interaction treatments of ($C_3 \times G_2$) and ($C_2 \times G_1$) respectively this may be due to greater secondary branches in C_2 row spacing of 60 cm as shown in (table 6).

Data in the same table illustrated that ($C_1 \times HA_2$) had highest number of capita plant^{-1} (28.56). Whereas, the lowest number of capita plant^{-1} (19.01) was attained from interaction treatment of ($C_1 \times HA_0$). It means that application of HA_2 alone is more effective for this trait. The interaction between plant geometry and humic acid also had significant effect on the mentioned trait.

Table 7: Effect of cultivar, plant geometry, humic acid and their interaction on Number of Capita Plant^{-1}:

Cultivar (C)	Humic acid HA	Geometry (G)		Means of		
		45cm	60cm	Cultivar	Humic acid	C*HA
Benglanuglue	0	18.65 hi	21.41 fg	23.22 b	19.95 c	20.03e
	350	21.32 fgh	25.84 bcd			23.58 bcd
	700	23.67 def	28.40 ab			26.04 ab
Karal	0	17.85 i	20.16 ghi	21.70 c	23.58 b	19.01e
	350	19.85 ghi	23.53 def			21.69 cde
	700	22.21 efg	26.60 bc			24.41bc

Animax	0	18.57 ^{i}	23.07 ^{ef}	24.95 ^{a}	26.33 ^{a}	20.82 ^{de}	
	350	24.37 ^{cde}	26.55 ^{bc}			25.46 ^{b}	
	700	26.99 ^{bc}	30.14 ^{a}			28.56 ^{a}	
Mean of	G	21.50 ^{b}	25.08 ^{a}				
	C *G	21.21^{cd}	25.22 ^{ab}	19.97 ^{d}	23.43 ^{bc}	23.31^{bc}	26.58^{a}
	G*HA	18.36 ^{d}	21.85 ^{c}	24.29 ^{b}	21.54 ^{c}	25.31^{b}	28.38^{a}

Mean values followed by the same letter are not significantly different at the 5% probability level according to Duncan test

The highest value (28.38) was observed from the interaction between (G_2×HA_2) this may be due to the single effect of them. Furthermore, the interaction treatment among the three studied factors (C× G ×HA) had a positive effect on number of capita plant^{-1}. The (C_3*G_2*HA_2) recorded the highest value (30.14) capita plant^{-1}. The interaction treatment (C_2×G_1 ×HA_0) recorded the lowest value (17.85) capita plant^{-1}.

Number of Seed Capita^{-1}:

Table (9) shows that the cultivars affected significantly on number of seed capita^{-1}, the highest value (3.26) was recorded for Animax cultivar (C_3), while the lowest value (2.00) was recorded from Benglanuglue cultivars(C_1).

The highest and lowest value (3.24 and 2.42) were recorded from G2 and G1 respectively as results in the same table. This similar result was founded by (Ukale, 2014) who reported that an increase in the number of seeds capitula^{-1} under the impact of wide spacing between rows. Whereas, the application of HA_2 (700 mg L^{-1}) with 46.28% increase in the number of seeds per pod which differ significantly with the control plants. Other levels of humic acid causes 24.45% increase comparing with control treatment.

It can be concluded that increase in the number of seeds capitula^{-1} as affected by humic acid applications is resulted from improving plant growth conditions and increasing the nutrients

This result in agreement with (Tadayyon et al., 2017) they reported that application of humic acid increased the number of seeds at Niger plant.

The interaction between cultivar and plant geometry influence significantly on number of seeds capitula$^{-1,}$ the interaction treatments (C_3*G_2) recorded the highest value (3.69), while the lowest value (1.55) was obtained from (C_1*G_1) these results agree with (Sharifi et al., 2012).

As shown in table (9) highest number of seeds capitula^{-1} (3.68) was recorded from the interaction of Karal cultivar(C_2) with the HA_2 (700 mg L^{-1}), while the minimum mean value (1.23) was recorded from interaction treatments of (C_1* HA_0) Thus, the mean values indicated that Karal cultivars(C_3) responded better than other cultivars to spraying of humic acid.

The interaction between plant geometry and humic acid was significant on the same trait. The highest and lowest number of seed captia^{-1} (3.72 and 1.91) were recorded form (G_2 × HA_2) and (G_1 × HA_1) respectively.

Furthermore, the interaction among the three studied factors affected significantly on number of seed capitula^{-1}. (C_2× G_2 × HA_2) showed the highest values (3.95) while the lowest value (0.87) recorded for the interaction treatment (C_1 ×G_1 ×HA_0) it means the studied factors caused 4.54 times increase in number of seeds capita^{-1}, or it means the interaction between the studied factors created different conditions for Niger growth ranged from worst to best condition.

Table 9: Effect of cultivar, plant geometry, humic acid and their interactions on Number of Seed Capita $^{-1}$:

Cultivar (C)	Humic acid HA	Geometry (G)		Means of		
		45cm	60cm	Cultivar	Humic acid	C*HA
Benglanuglue	0	0.87 ^{h}	1.59 ^{g}	2.00 ^{b}	2.29^{c}	1.23 ^{e}
	350	1.37 ^{g}	2.51 ^{ef}			1.94 ^{d}

	700	2.41 ^{ef}	3.27 ^{bc}			2.84 ^{bc}	
Karal	0	2.32 ^{f}	3.08 ^{cd}	3.22 ^{a}	2.85 ^{b}	2.70 ^{c}	
	350	2.89 ^{cde}	3.71 ^{ab}			3.30 ^{abc}	
	700	3.41 ^{bc}	3.95 ^{a}			3.68 ^{a}	
Animax	0	2.56 ^{def}	3.34 ^{bc}	3.26 ^{a}	3.35 ^{a}	2.95 ^{bc}	
	350	2.88 ^{cde}	3.78 ^{ab}			3.33 ^{abc}	
	700	3.10 ^{cd}	3.94 ^{a}			3.52 ^{ab}	
Mean of	G	2.42 ^{b}	3.24 ^{a}				
	C *G	1.55 ^{c}	2.46 ^{b}	2.87 ^{b}	3.58 ^{a}	2.84 ^{b}	3.69 ^{a}
	G*HA	1.91 ^{d}	2.38 ^{cd}	2.97 ^{bc}	2.67 ^{bc}	3.33 ^{ab}	3.72 ^{a}

Mean values followed by the same letter are not significantly different at the 5% probability level according to Duncan test .

Weight of 1000- Seeds (g):

Table (10) explain the significant effect of the studied factors of 1000 seeds weight, the highest values (3.38 ,3.35 and 3.66) g were recorded from C_3, G_2 and HA_2 respectively. These may be due to genetic factors, the role of plant density in additional to the great role of HA in increasing nutrient availability for plant, which caused increase in weight of 1000seeds, similar results were obtained by (Shaikh 2019) . As it was mentioned earlier, it seems that humic acid increases the photosynthetic activity of plants through acceleration of rubisco enzyme. In addition, by improving the production of sugar, protein and vitamins in plant, humic acid positively affects various aspects of photosynthesis and improves the quantity and quality of the food crops (Delfine et al., 2005).

The interaction between cultivars and levels of HA affect significantly on weight of 1000- seeds, the highest value (3.75) g and lowest value (1.97) g were recorded from interaction treatments of (C_3*HA_2) and (C_2*HA_0) respectively. Seed index affected significantly by the interaction between C × G and G x HA the highest value was recorded for (C_3x G_2) and (G_2 x HA_2) with values of (3.65 and 3.88) g respectively.

On the other hand, the interaction of (C_3*G_2 *HA_2) recorded the highest weight (3.91) g for 1000- seeds weight. the above treatment combination between two or three factors created the best growth conditions for plant.

Table 10: Effect of cultivar, plant geometry, humic acid and their interaction on 1000- Seed Weight (g):

Cultivar (C)	Humic acid HA	Geometry (G)		Means of			
		45cm	60cm	Cultivar	Humic acid	C*HA	
Benglanuglue	0	1.98 ^{e}	2.36 ^{de}	2.93 ^{b}	2.35 ^{c}	2.17 ^{c}	
	350	2.70 ^{d}	3.20 ^{c}			2.95 ^{b}	
	700	3.48 ^{abc}	3.85 ^{a}			3.67 ^{a}	
Karal	0	1.24 ^{f}	2.71 ^{d}	2.82 ^{b}	3.12 ^{b}	1.97 ^{c}	
	350	2.59 ^{d}	3.24 ^{c}			2.92 ^{b}	
	700	3.27 ^{bc}	3.88 ^{a}			3.58 ^{a}	
Animax	0	2.46 ^{d}	3.33 ^{bc}	3.38 ^{a}	3.66 ^{a}	2.90 ^{b}	
	350	3.29 ^{bc}	3.71 ^{ab}			3.50 ^{a}	
	700	3.60 ^{abc}	3.91 ^{a}			3.75 ^{a}	
Mean of	G	2.73 ^{b}	3.35 ^{a}				
	C *G	2.72 ^{bc}	3.14 ^{ab}	2.37 ^{c}	3.28 ^{ab}	3.12 ^{ab}	3.65 ^{a}
	G*HA	1.89 ^{d}	2.86 ^{c}	3.45 ^{b}	2.80 ^{c}	3.38 ^{b}	3.88 ^{a}

Mean values followed by the same letter are not significantly different at the 5% probability level according to Duncan test.

Seed Yield (kg ha^{-1}):

The seed yield affect significantly by cultivars, plant geometry and spraying with humic acid, as shown in table (11), the highest values were (547.46 ,549.04 and 664.74) kg ha^{-1} obtained from C_3, G_1 and HA_2 respectively, these results agree with those obtained (Kabade et al., 2006), (NakhZari Moghadam, 2009) and (Hamza, 2015).

The maximum seed yield was found by (700 mg L^{-1}) humic acid foliar application. As mentioned before, it seems that the positive effects of humic acid on foliage growth of Niger crops was higher in comparison with seed yield. The minimum seed yield was found by control treatment. This similar result was found by (Moraditochaee, 2012).

Moreover, the seed yield was significantly affected by the interaction between cultivar and humic acid (C * HA) on this trait. The highest value (691.09) kg ha^{-1} was obtained from (C_3 xHA_2), this explain the role of HA in the above interaction similar result was found by (bakry ahmed bakry, 2013).

Table 11: Effect of cultivar, plant geometry, humic acid and their treatment combinations on Seed Yield (kg ha $^{-1}$):

Cultivar (C)	Humic acid HA	Geometry (G) 45cm	60cm	Means of Cultivar	Humic acid	C*HA	
Benglanuglue	0	300.98^{e}	309.58^{e}	490.22^{b}	298.02^{c}	305.27^{c}	
	350	560.61^{cd}	505.38^{d}			532.99^{b}	
	700	754.10^{ab}	510.67^{d}			632.38^{ab}	
Karal	0	244.75^{e}	280.47^{e}	493.14^{b}	568..05^{b}	262.61^{c}	
	350	578.80^{cd}	513.31^{d}			546.06^{b}	
	700	727.64^{ab}	613.86^{bcd}			670.75^{a}	
Animax	0	340.67^{e}	311.68^{e}	547.46^{a}	664.74^{a}	326.17^{c}	
	350	674.72^{abc}	575.49^{cd}			625.11^{ab}	
	700	759.06^{a}	623.12^{a-d}			691.09^{a}	
Mean of	G	549.04^{a}	471.51^{b}				
	C *G	538.56^{a}	441.87^{a}	517.06^{a}	469.22^{a}	591.48^{a}	503.43^{a}
	G*HA	295.47^{c}	604.71^{b}	746.93^{a}	300.58^{c}	531.39^{b}	582.55^{b}

Mean values followed by the same letter are not significantly different at the 5% probability level according to Duncan test.

Table (11) refers to the significant effect of the interaction between plant geometry and spraying with HA, the highest and lowest values (746.93 and 295.47) kg ha^{-1} were observed from interaction treatments of (G_1 × HA_2) and (G_1 × HA_0) respectively, the increase in leaf area ,no. seed per capita and seed index as shown in table (6 , 9 and 10) in the mentioned interaction may be effect on increasing seed yield ,these results agree with (Emam and Awad, 2017).

The interaction between cultivars and geometry not affect significantly, while the interaction among the studied factors caused increase in yield, the highest seed yield (759.06 kg ha^{-1}) was recorded from (C_3*G_1*HA_2) while the lowest value (300.98 kg ha^{-1}) observed from (C_1*G_1*HA_0)

Biological Yield (kg ha^{-1}):

Table (12) explains significant effects of cultivars on biological yield, the highest value (2393) kg ha^{-1} was recorded for C_3 and lowest value (2048) kg ha^{-1} obtained for C_1 this may be due to genetic factors. The plant geometry (G) and HA application were affected significantly on this trait, the highest values (2431 and 3161) kg ha^{-1} were noted from G_1 and HA_2 respectively, these may be due to increase in plant density and role of humic acid in increasing availability for plant then increase in growth, similar results was recorded by (Safaei et al., 2014).

On the other hand, the biological yield significantly affected by the interaction between cultivar and humic acid (C × HA). The maximum biological yield (3463) kg ha^{-1} was attained from (C_3 × HA_2) whereas, the lowest biological yield (1210) kg ha^{-1} was noted from (C_3 ×HA_0). Similar result was found by (Karakurt et al., 2012)

Table (12) shows significant effect of the interaction between plant geometry and humic acids, the highest and lowest values was obtained from (G_1 x HA_2 and G_2 x HA_0) with the recorded values (3352 and 1180) respectively.

There is also significant effect of the interactions among cultivars, plant geometry and humic acid application (C × G × HA) on biological yield, indicating different response of Niger cultivar to foliar application of humic acid applied at different plant geometry. The highest biological yield (3633 kg ha^{-1}) was recorded when Animax cultivar was sprayed with (700 mg L^{-1}) at 45cm between the rows (C_3 × G_1 × HA_2). By contrast, the lowest amount of biological yield (930 kg ha^{-1}) was obtained from (C_3 × G_2 × HA_0).

Table 12: Effect of cultivar, plant geometry, humic acid and their treatment combinations on Biological Yield (kg ha^{-1}):

Cultivar (C)	Humic acid HA	Geometry (G)		Means of			
		45cm	60cm	Cultivar	Humic acid	C*HA	
Benglanuglue	0	1520^{ghf}	1230^{h}	2043^{b}	1323^{c}	1373^{e}	
	350	2310^{def}	1600^{fgh}			1960^{d}	
	700	3060^{a-d}	2540^{cde}			2800^{bc}	
Karal	0	1410^{gh}	1373^{g}	2331^{ab}	2228^{b}	1392^{e}	
	350	2580^{b-e}	2190 ^{efg}			2382^{cd}	
	700	3363^{ab}	3080^{a-d}			3220^{ab}	
Animax	0	1483^{gh}	930^{h}	2393^{a}	3161^{a}	1210^{e}	
	350	2523^{cde}	2500^{cde}			2510^{c}	
	700	3633^{a}	3293^{abc}			3463^{a}	
Mean of	G	2431^{a}	2080^{b}				
	C *G	2300^{a}	1790^{a}	2450^{a}	2212^{a}	2540^{a}	2450^{a}
	G*HA	1470^{c}	2470^{b}	3352^{a}	1180^{c}	2094^{b}	2970^{a}

Mean values followed by the same letter are not significantly different at the 5% probability level according to Duncan test

Harvest Index (%):

As indicated in table (13), an increase in humic acid caused increase in harvest index. The highest average values of the harvest index were registered at HA_1 which was (25.50) %, while the lowest average values of the harvest index (22.50) % was registered for HA_0.

As well as, the interaction between plant geometry and humic acid (G × HA) was amazing. One amazing and highest value was obtained from G_2 spacing and zero humic acid which gave (25.48%) harvest index only. While, 60 cm row spacing and (700 mg L^{-1}) gave lowest value (19.60%) of harvest index. Similar result were found by (Musazadeh et al., 2009) and (Ehsanzadeh and Baghdadabadi, 2003).

There are also significant interactions among C x HA and cultivars x plant geometry x humic acid application for harvest index. The highest harvest index recorded was (27.20 and 31.60) % recorded for (C_1x HA_1) and Benglanuglue cultivar with wider plant geometry and sprayed with (350 mg L^{-1}) of humic acid (C_1 × G_2 × HA_1). whilst, the lowest value (18.90 and 17.35) %was achieved from (C_2 x HA_0) and (C_2× G_1 × HA_0) respectively. This can be justified by the fact that the interaction treatment of spraying with humic acid was in all aspects superior in promoting yield parameters than the treatment without spraying humic acid application. These results agree with (Nasiri et al., 2017).

Table 13: Effect of cultivar, plant geometry, humic acid and their treatment combinations on Harvest Index % :

Cultivar (C)	Humic acid HA	Geometry (G) 45cm	Geometry (G) 60cm	Means of Cultivar	Means of Humic acid	Means of C*HA	
Benglanuglue	0	19.80^{c}	25.20^{abc}	24.00^{a}	22.50^{b}	22.22^{abc}	
	350	24.30^{abc}	31.60^{a}			27.20^{a}	
	700	24.65^{abc}	20.10^{c}			22.60^{abc}	
Karal	0	17.35^{c}	20.40^{b}	22.15^{a}	25.50^{a}	18.90^{c}	
	350	22.45^{b}	23.45^{b}			22.90^{abc}	
	700	21.65^{bc}	19.95^{c}			20.85^{bc}	
Animax	0	23.00^{b}	33.50^{ab}	22.90^{a}	21.03^{c}	26.95^{ab}	
	350	26.75^{abc}	23.00^{b}			24.90^{abc}	
	700	21.90^{c}	18.90^{c}			19.95^{c}	
Mean of	G	22.60^{a}	22.66^{a}				
	C *G	23.40^{a}	24.70^{a}	21.10^{a}	21.21^{a}	23.30^{a}	20.55^{a}
	G*HA	20.10^{ab}	24.50^{ab}	22.30^{ab}	25.48^{a}	25.40^{a}	19.60^{b}

Mean values followed by the same letter are not significantly different at the 5% probability level according to Duncan test.

Conclusion:

In light of current study, the most outstanding conclusions can be summarized that among treatments Animax cultivar, the 60 row spacing and spraying of 700 mm humic acid remained comparatively better regarding with other cultivars and 45 cm row spacing and the other humic acid applying for most of growth characters.

Animax cultivar recorded highest values in primary and secondary branches, leaf area index, chlorophyll content, no of capita plant^{-1}, no of seed capita^{-1}, weight of 1000. The 45 cm per rows resulted in leaf area index, seed and biological yield while, the 60 cm spacing recorded the highest values for the other studied traits. Spraying of 700 mg L^{-1} causes increase in most of the growth and yield parameters.

The treatment combination of (C_3*G_1*HA_2) recorded high yield ha^{-1}, it was also concluded that interaction treatments of (C_3*G_2*HA_2) found to be an optimum interaction which produce highest no of capita per plant and weight of 1000 seed and seed yield.

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