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Effect of plant density and Earthing up process on yield triats and components of sorghum cultivar (Bihawth 70)

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Abstract:
A field experiment was conducted at the experimental farm belong to Rabban A-Safiya company-Aureij site located in south of Baghdad to study the effects of plant densities and four dates of Earthing up after emergence on lodging percent, growth traits and grain yield and its components of sorghum crop (Bihawth 70 cultivar). The layout of the experiment was a split-plot in a Randomized Complete Block Design (RCBD) with three replicates. The main plots included four treatments of plant densities (53333, 66666, 80000 and 100000 plant ha^{-1}) while sub plots were four dates of Earthing up (control, 4 weeks, 5 weeks and 6 weeks) after emergence, sowing took place in the first half of August 2018. The results showed that the plants density 100000 plant ha^{-1} showed the highest grain yield (8.715-ton ha^{-1}) and biomass (27.583-ton ha^{-1}), While the plant grown at low density (53333 plant ha^{-1}) gave the highest number of grains per head (4332), weight of 1000 grain (27.600 g) and plant yield (119.540 g plant $^{-1}$). The date of four week Earthing up after emergence gave the lowest number of grains per head (4043 $head^{-1}$), weight of 1000 grain (26.875 g), grain yield (7.950-ton ha^{-1}) and biomass (20.517 ton ha^{-1}). There was a significant interaction between plant densities and earthing up, of the most studied traits except for 1000 grain weight and grain yield per unit area. Plant density 100000 plant ha^{-1} with date of four week earthing up after emergence gave grain yield (9.166 ton ha^{-1}) biomass (28.567 ton ha^{-1}), while the plant density of 53333 plant ha^{-1} with earthing up date of four weeks after emergence gave the highest average, number of grains in the head (4422 $head^{-1}$) and yield per plant (124.280 g) .It is clear from this study that the date of four week Earthing up after emergence of sorghum crop (Bihawth 70 cultivar) resulted in a reduction in the number of increased the yield per plant. Also, the increase of plant density led to increased competition among plants for growth factors, especially light, which led to an increase in some of vegetative growth traits resulting in an increase in grain yield per unit area, despite of the decrease in some grain yield components.

Keywords: sorghum, plant density, Earthing up, Bihawth 70

Introduction

sorghum (*Sorghum bicolor* L.) is the second-ranked cereal crop in biofuel production, as it is one of the most available renewable sources on earth and can be used in the future as an alternative to petroleum. It is also a forage and industrial crop, and interest in it has increased due to its high efficiency in exploiting environmental factors towards increasing the efficiency of the carbon

metabolism process and its reflection in increasing the grain and forage yield (Jones and Popham, 1997). The dry matter is from the four-carbon plant (C4), and the sorghum seeds are of high nutritional value, as they contain 70-80% carbohydrates, 11-13% protein, 2-5% fat, 1-3% fiber, 1-2% minerals. Sorghum protein does not contain gluten, which makes it a nutritional alternative for people with gastrointestinal diseases and diabetes (Prasad and Staggenborg, 2009). The productivity of any crop is only a reflection of the interaction between genetic structure, environmental conditions and field practices such as the number of plants and how they are distributed in the unit area and their effect on the geometric shape of the plant and the pattern of growth and development, and thus their impact on the yield (Gardner et al., 1990), determining the optimal level of plant density, it plays a key role in expressing the variety itself and giving it the highest yield (Atiya *et al*., 2001). Plant density directly affects plants' competition for water, light and nutrients. Knowing the best distribution of plant densities in the field based on the distances between the hollows and the lines gives the best overlap between the study factors, achieving the best yield in the production of sorghum. Several results from scientific studies agreed that reducing plant density led to an increase in the number of grains per head. Snider (2012) and May et al. (2016) noted in their study of the effect of plant density on yield and its components of sorghum, a significant increase in the number of grains in the head when reducing plant density. Bayu et al. (2005) showed that there were significant differences between plant density treatments 29629, 38095, 88888 and 166666 plants.ha^{-1} in the average number of grains per head, as the treatment of low plant density 29,629 plants ha^{-1} was superior to the highest average number of grains per head reached 2515 grains head^{-1} and did not differ significantly from the density 38059 plants.ha^{-1}, which amounted to (2440 grains head^{-1}), while it differed significantly from the high density 166,666 plants.ha^{-1}, that gave the lowest average of (1530 head^{-1} grains). Waheeb et al. (2017) concluded that the number of grains decreased with an increase in plant density by 436 and 809 grains than the number of grains of a plant in medium and high density as a result of increased competition between plants. This result agrees with the results of Al-Shugeairy et al. (2023) and Al-Salmani (2018), who indicated that the response of the trait was significant by the effect of cultivars and density, and the number of grains for all cultivars decreased with the increase in plant density, and the highest number of grains for all cultivars was at the low density. Earthing up is one of the crop managements and it is accomplished by covering the aerial roots at the base of the plant stems with soil (30-25) cm manually in the case of small areas or mechanically for large areas, because the aerial roots close to the surface of the soil are in a state of development and growth, but most of them do not It reaches the soil because it is short and cannot penetrate into the soil, as in the sorghum and maize crops. Therefore, the process of earthing up should be conducted for it (Al-Mutlabi, 1987 and Al-Alusi, 2005), as the earthing up process has many benefits for the plant, including increasing the growth of roots and their spread in the soil and thus increasing the ability of the plant to absorb water and nutrients and to stabilize and support plants. The process of earthing up and manual hoeing is also combined to combat harmful weeds and bushes that compete with plants for light, water and nutrients. In addition, the conduct of these two processes is important in maintaining soil moisture and soil temperature, as well as increasing the fragmentation of the solid surface layer of the soil that forms it. Irrigation and rain water, which leads to exposure of the soil to sunlight and air, and then increases crop growth and productivity (Al-jawaheri et al. 2020

; Chattha et al., 2010). Al-Dulaimi (2006) observed a significant increase in the yield of maize grain when covering the aerial roots with soil. The average grain yield in the treatment without fertilization was 9.14 tons.ha^{-1}, while the average grain yield in the fertilization treatment was 10.63 tons.ha^{-1} and the increase was 16.3% . This was confirmed by Shati and Al-Aboudi (2012) that the earthing up process was significantly superior to the highest average grain yield in the two seasons, which amounted to 10,922 and 9.162 tons ha^{-1}, compared to the method of cultivation on lines without stratification, which gave the lowest average in both seasons, which amounted to 9,450 and 8.667 tons ha.$^{-1}$ for the two seasons sequentially, and it indicates that the earthing up process in

maize caused an increase in the grain yield by 10.6%, and in the second season by 9.7%.This study aims to know the effect of plant densities and earthing up stages on growth triats and yield of sorghum crop (Bihawth 70) to determine the best plant density with the best earthing up stage to achieve the highest grain yield per unit area and reduce the rate of lodging.

Materials and Methods

A field experiment was carried out in the autumn season of 2018 in alluvial clay mixture of soil belonging to the experimental field of Rabban Al Safina Company - Awiraj area - south of Baghdad, for the purpose of studying the effect of the earthing up process and plant density on the growth triats, yield and components of sorghum Buhouth 70. The experimental plot was divided into experimental units in the order of split plot design and with three replications according to the RCBD complete plot design. The main plot included plant density (53333, 66666, 80000, 100000) plants h^{-1} and denoted by(D4,D3, D2, D1) sequentially, the distance between the holes and the lines (25 x 75, 20 x 50, 25 x 50, 25 x 50) cm sequentially. As for the sub-plots, they included the earthing up stages (without earthing up process, 4 weeks, 5 weeks, and 6 weeks) of emergence sequentially and denoted (E0, E1, E2, E3). Random samples were taken from different sites of field soil at a depth of (30) cm to study the physical and chemical properties of the soil and were analyzed in the laboratories of the General Authority for Agricultural Research - Abu Ghraib. The smoothing process was carried out with the disc harrows to ensure the preparation of a suitable bed for the seeds, and after the completion of the process of leveling the land, it was divided into 3 x 3 meter. Lines were opened for planting manually at the above-mentioned distances. The experiment land was fertilized with phosphate fertilizer mixed with the soil before planting at a level of 100 kg H-1 P2O5 in the form of triple superphosphate (P2O5 45%) at once before planting, while the nitrogen fertilizer was added in the form of urea (46 N%) at a rate of 400 kg h^{-1} N with three equal times, the first at planting, the second at a height of 30 cm for the plant, and the third at the beginning of flowering (Ministry of Agriculture, 2006).The experiment was manually planted on 10/8/2018 by placing 3 seeds in one hole, which dimmed to one plant after three weeks of planting. The pesticide diazinon (10% active substance) was used to control the *Sesamia critica* L. with an amount of 6 kg h^{-1} and in two times, the first in the stage of 4-5 leaves as a preventive control and the second after 15 days of the first control (Ministry of Agriculture, 2006). Weeding was carried out whenever needed to control the bush and the heads were wrapped after flowering before grain was formed to avoid damage to birds. Random samples consisting of five plants were selected from the two middle lines from each experimental unit to study the required field triats. The plants were harvested at the stage of full maturity. The data were analyzed according to the GenStat program and the arithmetic averages were compared according to the L.S.D test at a probability level of 0.05 (AL-Sahoki and Wahib, 1990) and the following triats were studied:

Number of grains per head (head bead^{-1})

It was calculated manually as the average number of grains per head for the five plants taken randomly at the harvest stage.

1000 grain weight (gm)

1000 grains were taken at random from the plants in which the number of grains for heads was calculated on the basis of 12% moisture in them and weighed with a sensitive scale after it was calculated manually.

Yield per plant (gm plant $^{-1}$)

It was calculated on the basis of the average dry seed yield of the plant from the five plants randomly selected from each experimental unit.

Grain yield (tons h^{-1})

It was estimated that the harvest of five plants for each experimental unit was extracted and its average yield was extracted and multiplied by the plant density according to the parameters, and the data was converted to ton h^{-1} based on 12% moisture.

Biomass (tons h^{-1})

Five plants were taken at random immediately after harvesting, they were cut and then dried naturally and after weight was fixed according to the average dry weight of one plant multiplied by the plant density to extract the weight of the total dry matter.
(Tetio and Gardner, 1988).

Results and discussion

Effect of plant densities and the sorting process on yield and its components

Number of grains per head (grain $head^{-1}$)

As the results of table (1) indicate that the plant density D1 treatment is significantly superior to the highest average number of grains In the head it was 4332 $head^{-1}$ grain and it did not differ significantly from plants grown with plant density D2 which gave 4170 $head^{-1}$ grain, while the plants grown with plant density D3 recorded an average of 3636 $head^{-1}$ grain. As for the plants grown with plant density D4, they gave the lowest mean for the trait which is 3506 $head^{-1}$ grains. The reason for the superiority of plants cultivated with plant density D1 in the number of grains in the head may be due to the increase in the efficiency of carbon metabolism, the increase in its output, and the regulation of its movement to the downstream sites in the breeding stage, which was positively reflected in the increase in the fertility and increase the number of grains in the head, as well as the role of the degree of the optimum temperature and appropriate relative humidity during the flowering period and its effect on maintaining pollen viability, which led to an increase in the percentage of pollination and fertilization, which in turn led to an increase in the average grain in the head and this is consistent with what was indicated by (Bayu *et al*, 2005) , a significant increase in the number of grains per head of when reducing the plant density. The results of Table (1) also showed that there were statistically significant differences between the stages earthing up in the average number of grains per head, the E1 plants gave the highest average of the trait which was 4043 grains of sorghum. $head^{-1}$ compared to the non- earthing up E0 plants giving the lowest mean for the trait of 3754 $head^{-1}$ grains. The increase in the number of grains in the head of the sorghum plant may be due to an increase in the proper absorption of ready-made elements and nutrients in the soil solution through the roots, which increases the ability of the soil to provide the plant with these multiplying elements in line with the needs of the plant and thus increase the efficiency of the process Carbon metabolism and thus increasing its products and regulating its transmission through source to the downstream in the reproduction stage, which was positively reflected on increasing the fertility and knots and increasing the number of grains in the head. This result was confirmed by the results obtained by Al-Aboudi and Al-Shatti (2014) that there was a significant increase in the number of grains per head of maize plant when the screening process was carried out. The effect of the interaction between plant density parameters and earthing up stages was significant on the number of grains per head of sorghum, as the interaction D1E1 gave the highest mean for the trait that reached 4422 grains of head-1, while the interaction D4E0 gave the highest value for the trait. The lowest average number of grains per head was 3386 grains $head^{-1}$.

1000 grain weight (gm)

The results of Table 2 showed that the plant density D1 was significantly superior to the plant density D1 treatment by giving it the highest mean of the trait 27.600 gm and did not differ significantly from the plant density D2, 27.417 g, while it differed significantly from the plant density D3 25,575 gm, while the plant density D4 recorded the lowest average for the trait amounted to 24,842 g.

Table 1. Effect of plant density and stages of earthing up on the number of grains head^{-1} of sorghum plant.

Mean	Stages of earthing up after emergence				(Plant Density (plant h^{-1})
	E3	E2	E1	E0	
4332	4393	4398	4422	4114	D1
4170	4098	4210	4361	4012	D2
3636	3597	3690	3751	3507	D3
3507	3411	3592	3637	3386	D4
	72.21				L.S.D%5
45.70	3875	3973	4043	3755	المتوسط
	35.69				L.S.D %5

The reason for the increase in the weight of the grain at low plant density and its decrease at the high plant density is due to the competition between plants for mineral nutrients, light and water, as well as the shading of the lower leaves, which causes aging and the reduction of the number of leaves, which is negatively reflected in the decrease in the products of carbon metabolism needed to fill the grain. This is consistent with what was indicated by Nahba (2004), Jiyad (2008) and Shehab (2011) that there was a significant increase in the grain weight of sorghum plants when reducing plant density. Also there are significant differences between the stages of earthing up in the average weight of one thousand grain of sorghum, as the E1 stage gave the highest average for the trait amounting to 26,875 g compared with treatment E0 (comparison treatment), which recorded the lowest average of 25.850 gm for the trait.

Table 2. Effect of plant density and stages of earthing up on the weight of 1000 kernels of sorghum (gm)

Mean	Stages of earthing up after emergence				Plant Density (plant h^{-1})
	E3	E2	E1	E0	
27.600	27.200	28.000	28.100	27.100	D1
27.417	27.067	27.600	28.000	27.000	D2
25.575	25.300	25.800	26.200	25.000	D3
24.842	24.867	25.000	25.200	24.300	D4
	N.S				L.S.D%5
0.368	26.108	26.600	26.875	25.850	Mean
	0.200				L.S.D %5

This may be attributed to this. To increase the efficiency of the aerial roots that were carried out in the average absorption of water and nutrients, that led to an increase in the effectiveness of the carbon metabolism process and thus an increase in the manufactured materials and their transfer

from the source to the downstream , thus increasing the weight of the grain. As for the effect of the interaction between plant density treatments and the stages of earthing up in the trait of weight of 1000 grains, it was not significant.

Yield per plant (gm plant $^{-1}$)

It was observed from the data in table (3) that the plants grown with plant density D1 were significantly superior to the highest average grain yield of 119,545 gm plant^{-1} compared to plants grown with plant density D2, which recorded 114,202 gm plant^{-1}, and plants grown with plant density D3, which gave 93.032 gm plant^{-1}. As for the plant density, D4 gave its plants the lowest mean of the trait, which was 87.150 gm plant-^{1}. Increasing the grain yield per plant of sorghum plants planted with low plant density D1 is a natural result, , which was positively reflected in the increase in the number of grains per head table(1) and the weight of a thousand grains table (2), and then increased one plant yield. Also, the results of table (3) show that there are significant differences between the stages of earthing up in the average yield of one plant of grain, as the plants of the E1 stage significantly outperformed the plants with the highest mean for the trait amounting to 109.100 gm plant^{-1} compared to non earthing up E0 (comparison treatment), which gave the lowest mean for the trait. It reached 97.367 gm plant^{-1}, due to the superiority of these plants in increasing the number of grains in the head (table 1) and the weight of a thousand grains (table 2) and then increasing the yield of one plant, while the interaction did not have a significant effect between the experimental treatments.

Table 3. Effect of plant density and stages of earthing up on yield of one plant of sorghum (gm plant^{-1})

Mean	Stages of earthing up after emergence				Plant Density (plant h^{-1})
	E3	E2	E1	E0	
119.545	119.490	123.170	124.280	111.240	D1
114.202	110.120	116.220	122.140	108.330	D2
93.032	91.020	95.210	98.300	87.600	D3
87.150	84.830	89.810	91.660	82.300	D4
	N.S				L.S.D%5
2.146	101.365	106.102	109.100	97.367	Mean
	1.530				L.S.D %5

Grain yield (tons h^{-1})

Table 4 showed that the plant density D4 treatment was significantly superior to the plant density treatment D4 with the highest average grain yield of 8.715 tons ha-1 compared to the cultivated plants. The plant density D3, which recorded 7.444 tons ha^{-1}, and the plants planted with plant density D2, which gave 7.613 tons ha-1, while the plant density D1 showed the lowest average 6.373 tons ha^{-1}, and the percentage of increase was 37.37%, the reason for the significant increase in the grain yield of **s**orghum plants. With a high density D4 led to an increase in the number of plants per unit area that compensated for the decrease in the number of grains in the head table(1), as well as the weight of the thousand grains table(2) and the yield of one grain plant table(3) for

the plants of the same treatment, and this confirms the results of Shehab (2011) and Mousavi et al. (2012) who found a significant increase in the yield of sorghum grain per unit area when plant density was increased. The results of table (4) show that there are significant differences between the stages of earthing up in the average grain yield of sorghum, as the plants of the E1 stage significantly outperformed the plants of the E1 stage with the highest mean of 7.950 tons ha^{-1} over the plants of the stage E2 and E3 7.726 and 7.369 tons ha^{-1} respectively, while the E0 plants (The comparison treatment) gave the lowest average grain yield of 7.099 tons ha^{-1}. The increase in grain yield of sorghum plants E1 is a natural result, which was positively reflected in the increase in the number of grains per head and the 1000 grain weight table (1, 2) and the yield of one plant table (3), and then the increase in the grain yield per unit area. This result is consistent with the results obtained by Al-Aboudi, Shatti (2014) and Al-Dulaimi (2006), who indicated that there was a significant increase in grain yield when the maize was earthing up. . As for the interaction effect, there was no significant effect between the treatments.

Table 4. Effect of plant density and stages of earthing up on the grain yield of sorghum plant (tonnes ha^{-1})

Mean	Stages of earthing up after emergence				Plant Density (plant h^{-1})
	E3	E2	E1	E0	
6.373	6.372	6.559	6.628	5.932	D1
7.613	7.341	7.747	8.142	7.221	D2
7.442	7.281	7.616	7.864	7.008	D3
8.715	8.483	8.981	9.166	8.230	D4
	N.S				L.S.D%5
0.114	7.369	7.726	7.950	7.097	Mean
	0.108				L.S.D %5

Biomass yield (tons h^{-1})

It was noticed from the results of the table 5 shows the superiority of the plant density D4 treatment significantly with the highest average biomass yield amounted to 27,583 tons ha^{-1} compared to plant density D3 21,100 tons.ha^{-1} and plant density D2 16,299 tons ha^{-1} while plant density D1 recorded the lowest average for the trait 12.608 tons ha^{-1}. The reason for the significant increase in the biomass yield of sorghum plants under high density D4 due to the increase in the number of plants per unit area as well as to the accumulation of dry matter, reflected in the increase in the grain yield of plants of the same treatment per unit area table. This result is in agreement with the findings of Chehab (2011) and Mousavi et al. (2012) who found a significant increase in the biomass yield of sorghum when plant density was increased. The results of table (5) showed that there are significant differences between the stratification stages in the average biomass yield of sorghum, as the plants of the E1 stage significantly outperformed the plants with the highest average of 20. 517 tons ha^{-1}, followed by the plants of the E2 and E3 stage with an average of 20.230 and 18.935 tons ha^{-1} sequentially, the plants of stage E0 (the comparison treatment) gave the lowest average biomass of 17.909 tons ha^{-1}. The effect of the sorting process led to the plants of this stage reaching early flowering with a duration of 64.420, which gives them a long opportunity to fill the bean and thus increase the biomass. Also, the plants of stage E1 earthing up after four weeks of emergence) were superior in yield characteristics and components such as number of head grains, grain weight, yield of one plant and grain yield per unit area (Table 1, 2, 3, 4). This was

through the effect of the tripping process on stimulating many vital processes within plant tissues, and this was reflected positively in increasing the biomass yield. This result is consistent with the results obtained by Al-Aboudi, Shatti (2014) and Al-Dulaimi (2006) that there was a significant effect of the earthing up process on the biomass yield of maize.The interaction showed a significant effect, as treatment D4E1 recorded the highest average in biomass of 28.567 tons ha^{-1} and did not differ significantly from treatment of D4E2 which gave a biomass yield of 28,367 tons.ha^{-1} compared to treatment D1E0 which gave the lowest mean of biomass yield of 11.573 tons ha^{-1} .

Table5. Effect of plant density and stages of earthing up on the biomass yield of sorghum plants

Mean	Stages of earthing up after emergence				Plant Density (plant h^{-1}
	E3	E2	E1	E0	
12. 608	11.964	13.279	13.617	11.573	D1
16.299	15.310	17.488	17.644	14.755	D2
21.100	21.333	21.787	22.240	19.040	D3
27.583	27.133	28.367	28.567	26.267	D4
	0.303				L.S.D%5
0.110	18.935	20.230	20.517	17.909	Mean
	0.168				L.S.D %5

Conclusions

We conclude from this study that the earthing up process of sorghum plants, cultivar 70, after four weeks of emergence, resulted in increase in the yield of one plant. Also, the increase in plant density led to an increase in competition between plants for growth factors, especially light, which led to an increase in some characteristics of vegetative growth, which resulted in an increase in the grain yield per unit area despite the decrease in some components of the yield.

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