

## INTERACTION EFFECT OF CHEMICAL AND ORGANIC FERTILIZERS ON THE YIELD AND YIELD COMPONENTS OF *Gundelia rosea* AT DIFFERENT PLANT DENSITIES IN THE FIELD

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### ABSTRACT

Field experiments were conducted at two locations, Grdarasha Research Field Station, College of Agricultural Engineering Sciences, Salahaddin University – Erbil and Aquaban special farm using randomized complete block design (RCBD) during two seasons 2019-2020 and 2020-2021 to study the effect of different plant densities and compost fertilizer of solid waste management and sorting of Akre district-Duhok province and NPK (20:20:20) fertilizer on growth and edible portion characteristics of *Gundelia rosea*. The results indicated that the plants of the two years age in the both locations produce the highest value of length, diameter, fresh and dry weight of edible portion with space increasing between plants and rows. While, total fresh and dry weight increased with decreasing the distance between plants and rows. Compost and compost + NPK fertilizer significantly increasing all edible portion parameters in both locations. The interaction between density and fertilizer resulted that D5 and compost and compost +NPK treatment produce the maximum rate of length, diameter, fresh and dry weight of edible portion, while D1 and compost and compost + NPK record the highest total fresh and dry weight production.

key words: Compost, NPK, Plant density, *Gundelia rosea*, recycling, sustainability

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تأثير التداخل بين السماد الكيميائي والسماد العضوي على الانتاج ومكونات الانتاج لنبات *Gundelia rosea* بكثافات نباتية مختلفة في الحقل

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مدرس

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المستخلص

أجريت التجربة في موقعين الاولى في محطة أبحاث حقل كرده ره شه , التابعة لكلية علوم الهندسة الزراعية, جامعة صلاح الدين-أربيل والثانية في حقل خاص في منطقة أقوبان باستخدام تصميم القطاعات العشوائية الكاملة خلال الموسمين الزراعيين من 2019-2020 و 2020-2021 لدراسة تأثير كثافات نباتية مع سماد الكومبوست المنتج من النفايات الصلبة المفروزة في منطقة أكري في محافظة دهوك وسماد ( NPK ) بتركيز ( 20:20:20 ) في النمو وصفات الجزء الذي يؤكل لنبات العكوب الجبلي *Gundelia rosea* . أشارت النتائج الى ان النبات في الموسمين للموقعين انتجت اعلى قيمة لكل من الارتفاع, القطر, الوزن الرطب و الوزن الجاف للجزء الصالح للأكل للنبات مع زيادة المسافة بين النباتات وبين الخطوط , بينما الحاصل الكلي للوزن الرطب و الوزن الجاف زادت مع تقليل المسافات بين النباتات وبين الخطوط. سماد الكومبوست و سماد الكومبوست + NPK سبب زيادة معنوية لجميع الصفات المدروسة للموقعين. التداخل مابين المسافات النباتية و التسميد اظهرت D5 مع سماد الكومبوست و سماد الكومبوست + NPK اعطى اعلى نسبة لكل من الارتفاع, القطر, الوزن الرطب و الوزن الجاف للجزء الصالح للأكل للنبات, بينما D1 مع سماد الكومبوست و سماد الكومبوست + NPK سجلت اعلى حاصل كلي للوزن الرطب و الوزن الجاف.

الكلمات المفتاحية: كومبوست، نترجين، فسفور، بوتاسيوم، كثافة نباتية، اعادة تدوير، استدامة

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## INTRODUCTION

*Gundelia rosea* is a perennial plant belonging to the Asteraceae family, found in the plains and mountains of Iraq, Iran, Jordan, Palestine, Syria, Azerbaijan, Armenia and Turkey (25) and well known in Iraqi Kurdistan Region for different purpose (15). The underground portion is edible as marketable fresh yield commonly used by people as a vegetative cooking dish. The dry seeds locally named (Ce Ce) using as a nut (6). Fertilizers are any materials or mixture utilized to supply one or more of essential plant nutrient components, macronutrients major essential nutrients such as NPK effects on plant growth yield increases and quality improvement of crops (30). In other hand, Aziz (6) in his study on NPK application at levels (0, 50, 100, 150 and 200 kg/donum) to Kanger plant (*Gundelia tournefortii* L.). He concluded that NPK application significantly affected on vegetative and edible portion parameters. The maximums rate of plant height with and without edible portion were about (24.12cm and 31.82cm) respectively, length of edible portion was 15.3cm, leaves length 24.70cm, fresh weight of edible portion 73.7g/plant, Number of seed per plant 21.67g and seed weight 9.06g. Compost raises the soil nitrogen and phosphorus accessibility, and enhanced plant growth to maximum value (1, 2, 3, 9). A study was performed by Ghaly and Alkokaik (16) to determine the effect of municipal solid waste (MSW) compost and NPK fertilization on growth and production of three types of crops (potatoes, corn and squash). The results revealed that the good plant growth and yield of potatoes and corn were given with application MSW compost, while NPK fertilizer have been produced the maximum plant growth and yield of squash when compared with control. Plant densities is very essential factors for yield and yield component production which is related to direct adequate sowing rates especially, for new adapted plant and crop production (19, 23, 28). Amedie (4) concluded that plants in general could be growing in various environmental and climate variably could be positive or negative impact, for instance temperature and CO<sub>2</sub> directly effect on the rate of photosynthesis, respiration and other biogeochemical processes, also

when the soil temperature raise the decomposition rate of organic matter increase and then the availability and mineralization of nutrient for plants uptake increase.

## MATERIALS AND METHODS

Experiments were conducted at two locations, Grdarasha Research Field, Collage of Agricultural Engineering Sciences, Salahaddin University – Erbil and Aquban village Farm, Shaqlawa distract - Erbil for two seasons to study ecological adapting of *Gundelia rosea* L. during November 1<sup>st</sup>, 2019 to April 1<sup>st</sup>, 2021. Grdarasha Research Field is locating at 36. 40° N, 44.10° E and at an elevation 470m above sea level and Aquban filaga is locating at 36.30° N, 44.47° E and at an elevation 926m above sea level. Representative air – dried soil samples were taken for both fields at the depth (0-30cm), then sieved with 2mm mesh and analyzed for some physical and chemical properties as shown in Table (1). *Gundelia rosea* seeds were obtained from the Barzan seed production factory – Erbil, the seeds were sown in field on November 1<sup>st</sup>, 2019 at depth of 6-7cm (6). during the experimental period plants were irrigated as necessary with sprinkler irrigation and manual weed control repeated more than once. In Grdarasha and Aquban were conducted this experiment to study the effect of compost fertilizer and NPK fertilizers at different plant spaces between rows and plants (10, 15, 20, 25 and 30cm) called (D1, D2, D3, D4 and D5) providing a density of about (100, 44.44, 25, 16 and 11 plant/m<sup>2</sup>) respectively in a plot with dimensions (2m × 2m) area with three replications, resulting 60 plots in each location. The chemical fertilizer NPK (20:20:20) was added to the soil with rate 16kg/ ha (6) and the compost fertilizer 30 ton/ha (24) before sowing of seeds. Compost (household organic waste) was obtained from (MRF Group – Akre Recycling Company - Duhok). Representative air – dried compost sample, then sieved with 2mm mesh and analyzed by using XRF (X-ray fluorescence spectrophotometer) Sky Instrument Genius, using Handheld thermal scientific Genius 9000 XRF for heavy metals (13). NPK and organic matter analyzed by using soil nutrient analyzer instrument. Some physical and chemical properties of compost as shown in Table (2).

**Table 1. Some of chemical and physical properties of the soil of Grdarasha and Aquaban village**

Soil properties	Grdarasha Field	Aquban Field	Soil properties	Grdarasha Field	Aquban Field
Sand %	12.5	22.82	Chromium (Cr) ppm	70	79
Slit %	42.5	41.73	Manganese (Mn) ppm	290	468
Clay %	45	35.44	Cobalt (Co) ppm	12	15
Texture Class	Silty clay	Clay loam	Copper (Cu) ppm	34	34
pH	8.02	7.93	Zinc (Zn) ppm	49	101
Electrical conductivity (EC) Ms.cm <sup>-1</sup>	135.8	207	Cadmium (Cd) ppm	0.1	0.1
Organic matter (O.M) mg/ml	4.52	6.7	Vanadium (V) ppm	86	83
Nitrogen (N) ppm	23.2	113.6	Nickel (Ni) ppm	141	177
Phosphor (P) ppm	28	30	Lead (Pb) ppm	1.04	0.96
Potassium (K) ppm	107	115	Iron (Fe) %	3.3	3.9

**Table 2. Some of chemical and physical properties of compost fertilizer**

Properties	Compost fertilizer components	Properties	Compost fertilizer components
Electrical conductivity (EC) Ms.cm <sup>-1</sup>	7.3	Cobalt (Co) ppm	9
pH	7.48	Copper (Cu) ppm	533
Organic matter (O.M) mg/ml	17.01	Zinc (Zn) ppm	136
Nitrogen (N) ppm	40	Cadmium (Cd) ppm	0.2
Phosphor (P) ppm	24	Vanadium (V) ppm	0.0
Potassium (K) ppm	80	Nickel (Ni) ppm	118
Chromium (Cr) ppm	43	Lead (Pb) ppm	121
Manganese (Mn) ppm	33	Iron (Fe) %	2.9

**Experimental parameters**

1-Length of edible portion (cm) was measured by ruler and diameter (mm) by using Vernier.

2-Fresh weight of edible portion (g) were weighted after removes roots soil residue and all leaves by sensitive electronic balance.

3-Dry weight of edible portion (g) was measured after oven dried to constant weight at 75°C for 72hours, when the color of edible portion turned to yellow color then, weighted by sensitive electronic balance.

4-Total yield (g.m<sup>-1</sup>) was calculated from the weighted marketable and non-marketable edible portion (g.m<sup>-1</sup>) for all plants in the experimental unit.

The experiment was carried out according to randomized complete block design (RCBD) with three replicates, comparisons between means were done using Duncan's Multiple Range at 5% level for morphological characteristics. The Comparisons were made between Grdarasha and Aquaban using t-test. The statistical analysis was carried out by using SPSS (Statistical Package for Social Sciences) Program, version (22.0) in 2019 (32, 14).

**RESULTS AND DISCUSSION****1. Edible portion characteristics in Grdarasha research field station****A. Effect of plant density**

Tables (3 and 4) shows the effect of density on edible portion parameters in Grdarasha. The results clarified that the highest value of length of edible portion (6.38 cm) in the first year of growing was recorded for D1 while, no significant effect was found in the second year. Fresh and dry weight of edible portion gradually evaluated with increasing of the space between plants and rows for the two growing seasons. The maximum rate of total fresh weight and total dry weight were obtained by D1 and minimum rate by D5 for the years.. The maximum yield is related to growth and development the plant in favorable environmental conditions and the closer distance between the plant and row accommodates a greater number of plants per unit area (18).

**B. Effect of fertilizer:** According to the results shows in the Tables (5 and 6), the compost fertilizer and compost + NPK occupy the first position for all edible portion characteristics in both growing seasons and the lowest value was recorded by control. Compost fertilizer stimulate the yield and rise the availability of trace elements like (Cd, Cr, Cu, Fe, Mn, Ni, Pb and Zn) in the soil, and these elements have many physiological effects on the plant (17). NPK application increase the yield, growth and quality of crops (30).

**C. Interaction effect between density and fertilizer:** The results of interaction between density and fertilizer were significantly influenced all the studied edible portion parameters in Grdarasha location in the both growing seasons (Tables 7 and 8). The highest measure (7.18 cm) of edible portion length was found in D1 and compost treatment while, (8.91mm) for the diameter of edible portion was recorded in D5 and compost + NPK treatment in the first year. But, in the second year of growth length and diameter of edible portion give the maximum value (9.92 cm) and (21.20 mm) with D2 and compost and compost + NPK fertilizer. In the both growing seasons

D4 and compost + NPK gave the highest grades (3.30g and 25.11g) respectively of fresh weight of edible portion, and D5 and compost + NPK recorded maximum dry weight of edible portion (0.51g and 1.49g) respectively. D1 and compost and compost + NPK occupy the first position for total fresh and dry yield of edible portion when compared with other treatments and the lowest value was recorded by D5 and control in both years. The similar results have been reported by Sinta and Garo (26), and Tamiru *et al.* (29) concerning Beetroot plant. El-Desuki *et al.* (10) reported that decreasing the space between plants may be due to competition for nutrients especially nitrogen, however increasing plant density give the higher ground cover by leaf area which is resulted highest light interception and maximum assimilate production. Heavy metals are present in the environment and also absorbed by plants, the presence of a modest quantity of heavy metals in the compost is there acceptable (5). Wiedenhoft (33) showed that macronutrients like nitrogen, phosphor, potassium, sulfur, calcium and magnesium which are required in relatively large amount by most plants.

**Table 3. Response of some edible portion characteristics to different density in Grdarsha in the (2019-2020)**

Density	Length of edible portion (cm)	Dimeter of edible portion (mm)	Fresh weight of edible portion (g)	Total fresh weight of edible portion (g.m <sup>-1</sup> )	Dry weight of edible (g)	Total dry weight of edible (g.m <sup>-1</sup> )
D1	6.38 a	5.14 c	1.31 c	131.33 a	0.24 d	24.91 a
D2	5.92 ab	6.36 b	1.47 bc	65.54 b	0.26 cd	11.7 b
D3	5.68 b	6.89 ab	1.81 b	45.41 c	0.32 bc	8.04 c
D4	5.81 ab	7.7 a	2.41 a	38.69 cd	0.37 ab	5.92 d
D5	6.13 ab	7.81 a	2.36 a	26 d	0.41 a	4.6 d

**Table 4. Response of some edible portion characteristics to different density in Grdarsha in the (2020-2021)**

Density	Length of edible portion (cm)	Dimeter of edible portion (mm)	Fresh weight of edible portion (g)	Total fresh weight of edible portion (g.m <sup>-1</sup> )	Dry weight of edible (g)	Total dry weight of edible (g.m <sup>-1</sup> )
D1	8.19 a	15.61 a	12.35 b	1235.49 a	0.82 b	82.61 a
D2	8.6 a	17.54 a	14.78 a	657.21 b	0.99 a	44.18 b
D3	8.55 a	16.82 a	14.96 a	374.1 c	0.99 a	24.76 c
D4	8.31 a	16.65 a	15.06 a	238.31 d	1 a	16.02 d
D5	9.02 a	16.56 a	15.11 a	166.25 d	1.06 a	11.69 d

**Table 5. Response of some edible portion characteristics to different types of fertilizer in Grdarsha in the (2019-2020)**

Density	Length of edible portion (cm)	Dimeter of edible portion (mm)	Fresh weight of edible portion (g)	Total fresh weight of edible portion (g.m <sup>-1</sup> )	Dry weight of edible (g)	Total dry weight of edible (g.m <sup>-1</sup> )
Control	5.48 b	5.72 b	1.27 c	38.89 c	0.21 c	7.4 b
NPK	5.59 b	5.87 b	1.52 c	49.11 c	0.27 b	8.86 b
Compost	6.63 a	7.66 a	2.18 b	71.13 b	0.39 a	13.23 a
Compost+NPK	6.23 a	7.88 a	2.52 a	86.45 a	0.41 a	14.63 a

**Table 6. Response of some edible portion characteristics to different types of fertilizer in Grdarsha in the (2020-2021)**

Density	Length of edible portion (cm)	Dimeter of edible portion (mm)	Fresh weight of edible portion (g)	Total fresh weight of edible portion (g.m <sup>-1</sup> )	Dry weight of edible (g)	Total dry weight of edible (g.m <sup>-1</sup> )
Control	8.03 b	13.98 b	10.92 b	395.01 b	0.75 b	27.31 b
NPK	8.31 ab	15.65 b	13.07 b	455.16 b	0.89 b	31.85 b
Compost	9.05 a	17.84 a	16.62 a	674.62 a	1.13 a	44.76 a
Compost+NPK	8.74 ab	19.08 a	17.2 a	612.29 a	1.12 a	39.49 a

\*The similar letters between treatments means there are no significant differences between them using Duncan's Multiple Test at 5% level.

**Table 7. Interaction effect of density and fertilizer on some edible portion characteristics in Grdarsha (2019-2020)**

Interaction Density × Fertilization	Length of edible portion (cm)	Dimeter of edible portion (mm)	Fresh weight of edible portion (g)	Total fresh weight of edible portion (g.m <sup>-1</sup> )	Dry weight of edible (g)	Total dry weight of edible (g.m <sup>-1</sup> )	
D1	Control	5.77 b-e	4.41 ef	0.78 i	78.66 cde	0.17 ij	17.33 c
	NPK	5.99 a-e	4.19 f	0.95 ghi	95.33 c	0.19 ij	19.00 c
	Compost	7.18 a	5.56 def	1.52 d-i	152.33 b	0.28 e-j	28.66 b
D2	NPK + Compost	6.57 abc	6.42 cde	1.99 c-f	199.00 a	0.34 c-h	34.66 a
	Control	5.52 cde	5.53 def	0.88 hi	39.10 fg	0.15 j	6.96 d-g
	NPK	5.40 cde	5.28 def	1.35 e-i	60.29 def	0.20 hij	9.03 def
D3	Compost	6.90 ab	7.35 def	1.66 d-h	73.77 cde	0.34 c-h	15.25 c
	NPK + Compost	5.86 b-e	7.28 a-d	2.00 c-f	89.02 cd	0.35 c-g	15.55 c
	Control	5.27 de	5.49 def	1.20 f-i	30.08 fg	0.22 g-j	5.50 efg
D4	NPK	5.38 cde	5.82 def	1.61 d-i	40.25 fg	0.28 e-j	7.08 d-g
	Compost	5.88 b-e	7.98 abc	2.10 cde	52.58 efg	0.38 a-f	9.58 de
	NPK + Compost	6.19 a-e	8.29 abc	2.35 bcd	58.75 def	0.40 a-e	10.00 d
D5	Control	5.24 e	6.55 cd	1.66 d-h	26.56 fg	0.25 f-j	4.05 g
	NPK	5.42 cde	7.09 a-d	1.76 d-g	28.16 fg	0.31 d-i	5.01 f-g
	Compost	6.65 abc	8.68 ab	2.95 ab	47.25 efg	0.45 a-d	7.25 d-g
D4	NPK + Compost	5.93 b-e	8.48 abc	3.30 a	52.80 efg	0.46 abc	7.36 d-g
	Control	5.59 cde	6.61 bcd	1.82 d-f	20.05 g	0.29 e-j	3.19 g
	NPK	5.78 b-e	6.96 a-d	1.95 c-f	21.52 g	0.38 a-f	4.21 g
D5	Compost	6.54 a-d	8.75 a	2.70 abc	29.73 fg	0.49 ab	5.39 e-g
	NPK + Compost	6.61 abc	8.91 a	2.97 ab	32.70 fg	0.51 a	5.61 e-g

**Table 8. Interaction effect of density and fertilizer on some edible portion characteristics in Grdarsha (2020-2021)**

Interaction Density × Fertilization		Length of edible portion (cm)	Dimeter of edible portion (mm)	Fresh weight of edible portion (g)	Total fresh weight of edible portion (g.m <sup>-1</sup> )	Dry weight of edible (g)	Total dry weight of edible (g.m <sup>-1</sup> )
D1	Control	6.55 c	12.25 e	8.31 g	831.60 dc	0.56 i	56.80 cd
	NPK	8.62 abc	13.79 de	9.95 fg	995.56 c	0.68 hi	68.26 c
	Compost	9.14 ab	18.86 abc	17.84 ab	1784.60 a	1.19 a-d	119.26 a
	NPK + Compost	8.46 abc	17.54 a-d	13.30 b-f	1330.20 b	0.86 d-i	86.13 b
	Control	8.66 abc	15.90 b-e	12.27 c-g	545.60 d	0.89 c-h	39.72 ef
D2	NPK	7.49 bc	14.26 cde	11.97 d-g	532.00 e	0.95 b-i	42.30 def
	Compost	9.92 a	18.81 abc	17.00 abc	775.88 d	1.03 a-g	45.78 de
	NPK + Compost	8.32 abc	21.20 a	17.89 ab	795.35 d	1.10 a-f	48.91 de
	Control	9.15 ab	13.99 cde	11.85 d-g	296.35 fgh	0.77 f-i	19.48 hg
	NPK	8.07 abc	16.72 a-e	14.15 b-f	353.86 efg	0.93 b-h	23.43 hg
D3	Compost	8.77 ab	17.27 a-d	16.48 a-d	412.19 ef	1.12 a-e	28.00 fg
	NPK + Compost	8.22 abc	19.29 ab	17.35 ab	433.99 ef	1.12 a-d	28.12 fg
	Control	7.71 abc	14.44 b-e	11.55 efg	184.81 gh	0.79 e-i	12.70 gh
D4	NPK	7.92 abc	17.56 a-d	14.39 b-f	230.29 fgh	0.89 c-h	14.29 gh
	Compost	8.34 abc	15.34 b-e	14.18 b-f	226.97 fgh	1.05 a-f	16.88 gh
	NPK + Compost	9.28 ab	19.26 ab	20.11 a	311.16 fgh	1.26 ab	20.21 gh
D5	Control	8.09 abc	13.32 de	10.60 efg	116.68 h	0.71 ghi	7.86 h
	NPK	9.48 ab	15.89 b-e	14.91 b-e	164.08 gh	0.99 b-h	10.95 h
	Compost	9.08 ab	18.92 abc	17.59 ab	193.50 gh	1.26 ab	13.88 gh
	NPK + Compost	9.42 ab	18.10 a-d	17.34 ab	190.75 gh	1.28 a	14.08 gh

\*The similar letters between treatments means there are no significant differences between them using Duncan's Multiple Test at 5% level

## 2. Edible portion characteristics in Aquaban village

**A. Effect of plant density:** Tables (9 and 10) present some characteristics of edible portion in Aquaban village. Statistical analysis of the data showed no significant effect between the studied densities on the length of edible portion in the first year and the highest value (8.11 cm) for D3 in the second year. D5 give the maximum rate (8.21 and 17.2mm) respectively of diameter of edible portion and the lowest value (6.5mm and 14.45mm) respectively recorded by D1 in both growing seasons. D4 and D5 recording the top value in fresh and dry weight of edible portion while, lowest rate obtained by D1 in the two years of study. The maximum data of total fresh and dry weight of edible portion were found by D1 and the minimum score was recorded by D5 for the years. These results are in accordance with Umar *et al.* (31) concerning radish plant. With increasing the distance between plants and rows could be less expose to intra-specific competition for light, moisture and nutrients, therefore tended to grow vigorously (22).

**B. Effect of fertilizer:** Tables (11 and 12) illustrates the effect of chemical and organic

fertilizer on some edible portion characteristics Aquaban location in two growing seasons. Compost and compost + NPK significantly increased all parameters for both years when compared with other treatments and the smallest rate for the parameters were recorded by control. These results in agreement with findings of Zerga and Tsegaye (34) concerning Carrot plant, BL Lanna *et al.* (8) concerning Radish plant and Elsharkawy (12) concerning Potato plant. Eldridage *et al.* (11) explained that the compost application resulted significant effect and sustained response in the soil biology. The application of NPK fertilizer have different metabolic processes in plant life (21, 30).

**C. Interaction effect between density and fertilizer:** Tables (13 and 14) shows the Interaction effect of density and fertilizer on some edible portion characteristics in Aquaban field in two years. The results observed that the highest value (6.93cm) was obtained of length of edible portion with D4 and compost + NPK and the highest measures (9.25m, 3.91g and 0.55) for diameter, fresh weight and dry weight of edible portion respectively were observed by D5 and compost + NPK in the

first year. But, in the second year D2 and NPK significantly increased the length of edible portion, while D3 and compost gave the maximum rate (21.66 mm) of diameter of edible portion. The highest fresh weight (19.42g) was recorded by D4 and compost and dry weight (1.24 by D5 and compost. D1 and compost + NPK registered the maximum total fresh and dry weight of edible portion. The similar results have been reported by Umar *et al.* (31) concerning Radish plant, Mijwel *et al.* (20) concerning Potato plant, and El-Desuki *et al.* (10) concerning Radish plant. Crowded plant populations with narrow intra-row distance leads to exert pressure on plant growth resources like, nutrients and light and then tended to poor growth (31). Tripathi *et al.* (30) mentioned that the macronutrients have a main role in different metabolic processes in the plant and required in a large amount for survival. In general, compost application

before sowing has a positive impact on improvement the physical properties of the soil and yield production (27).

**3. Comparison edible portion characteristics between Grdrash and Aquaban:** Regarding to the results that shows in the Table (15), no significant differences was found between Grdarasha and Aquaban for all edible parameters in the first year of trail. The edible parameters significantly increasing of Grdarasha field when compared with Aquaban in the second year. Baker and Capel (7) reported that the range of environmental conditions conducive to the production of crops is wide, and particular combinations of these environmental conditions allow specific crops to be grown in certain areas. Environmental factors that influence the extent of crop agriculture are, climate, soil properties, soil water elevation and slope.

**Table 9. Response of some edible portion characteristics to different density in Aquaban in the (2019-2020)**

Density	Length of edible portion (cm)	Dimeter of edible portion (mm)	Fresh weight of edible portion (g)	Total fresh weight of edible portion (g.m <sup>-1</sup> )	Dry weight of edible (g)	Total dry weight of edible (g.m <sup>-1</sup> )
D1	6.31 a	6.5 c	1.5 c	150.75 a	0.26 d	26.08 a
D2	6.69 a	6.75 bc	1.61 c	71.8 b	0.26 d	11.96 b
D3	6.73 a	7.16 bc	2.22 b	55.68 c	0.3 c	7.6 c
D4	6.67 a	7.66 ab	2.72 a	43.57 d	0.4 b	6.54 c
D5	6.44 a	8.21 a	2.99 a	32.98 e	0.44 a	4.92 d

**Table 10. Response of some edible portion characteristics to different density in Aquaban in the (2020-2021)**

Density	Length of edible portion (cm)	Dimeter of edible portion (mm)	Fresh weight of edible portion (g)	Total fresh weight of edible portion (g.m <sup>-1</sup> )	Dry weight of edible (g)	Total dry weight of edible (g.m <sup>-1</sup> )
D1	7.47 b	14.45 b	11.02 b	1102.37 a	0.7 b	70.82 a
D2	7.38 b	14.83 b	11.26 b	500.46 b	0.81 b	36.25 b
D3	8.11 a	16.34 a	12.36 b	309.05 c	0.78 b	19.68 c
D4	8.09 a	16.85 a	14.96 a	239.39 cd	0.94 a	15.1 cd
D5	7.67 ab	17.2 a	14.18 a	155.98 d	1.01 a	11.12 d

**Table 11. Response of some edible portion characteristics to different types of fertilizer in Aquaban in the (2019-2020)**

Density	Length of edible portion (cm)	Dimeter of edible portion (mm)	Fresh weight of edible portion (g)	Total fresh weight of edible portion (g.m <sup>-1</sup> )	Dry weight of edible (g)	Total dry weight of edible (g.m <sup>-1</sup> )
Control	6.24 b	6.5 b	1.68 c	52.04 d	0.25 d	8.56 d
NPK	6.5 ab	6.8 b	1.92 c	60.22 c	0.3 c	10.63 c
Compost	6.7 a	7.69 a	2.45 b	81.39 b	0.37 b	12.28 b
Compost+NPK	6.82 a	8.09 a	2.79 a	90.17 a	0.41 a	14.21 a

**Table 12. Response of some edible portion characteristics to different types of fertilizer in Aquaban in the (2020-2021)**

Density	Length of edible portion (cm)	Dimeter of edible portion (mm)	Fresh weight of edible portion (g)	Total fresh weight of edible portion (g.m <sup>-1</sup> )	Dry weight of edible (g)	Total dry weight of edible (g.m <sup>-1</sup> )
Control	7.29 c	12.78 c	9.09 c	336 b	0.59 c	21.18 b
NPK	7.54 bc	15.41 b	12.83 b	479.96 a	0.82 b	30.62 a
Compost	7.91 ab	18.27 a	14.47 a	471.28 a	0.98 a	33.77 a
Compost+NPK	8.24 a	17.28 a	14.62 a	558.56 a	1 a	36.79 a

\*The similar letters between treatments means there are no significant differences between them using Duncan's Multiple Test at 5% level

**Table 13. Interaction effect of density and fertilizer on some edible portion characteristics in Aquaban (2019-2020)**

Interaction Density × Fertilization	Length of edible portion (cm)	Dimeter of edible portion (mm)	Fresh weight of edible portion (g)	Total fresh weight of edible portion (g.m <sup>-1</sup> )	Dry weight of edible (g)	Total dry weight of edible (g.m <sup>-1</sup> )	
D1	Control	5.68 b	6.05 d	1.07 j	107.33 b	0.19 i	19.33 c
	NPK	6.30 ab	6.57 bcd	1.19 hij	119.33 b	0.25 ghi	25.00 b
	Compost	6.56 ab	6.76 bcd	1.81 e-j	181.33 a	0.27 fgh	27.00 b
	NPK + Compost	6.68 ab	6.97 a-d	1.95 e-j	195.00 a	0.33 c-f	33.00 a
D2	Control	6.42 ab	6.25 d	1.11 ij	49.47 fgh	0.21 hi	9.48 efg
	NPK	6.62 ab	6.04 d	1.44 g-j	64.28 efg	0.25 ghi	11.11 ef
	Compost	6.78 ab	7.28 a-d	1.86 e-i	82.65 cd	0.28 e-h	12.59 de
	NPK + Compost	6.95 a	7.43 a-d	2.04 d-g	90.80 c	0.33 c-f	14.66 d
D3	Control	6.48 ab	6.51 cd	1.69 f-j	42.41 ghi	0.21 hi	5.41 h-k
	NPK	6.65 ab	6.79 bcd	2.03 d-g	50.83 fgh	0.28 e-h	7.08 g-j
	Compost	6.88 a	7.40 a-d	2.37 c-f	59.33 efg	0.35 c-f	8.75 fgh
	NPK + Compost	6.92 a	7.93 a-d	2.80 bcd	70.16 de	0.36 cd	9.16 fg
D4	Control	6.43 ab	6.72 bcd	2.23 def	35.78 hi	0.31 d-g	4.96 ijk
	NPK	6.50 ab	6.82 bcd	2.39 c-f	38.24 hi	0.35 cde	5.65 h-k
	Compost	6.80 ab	8.23 a-d	3.02 bc	48.42 fgh	0.46 b	7.46 g-j
	NPK + Compost	6.93 a	8.87 ab	3.24 b	51.84 fgh	0.50 ab	8.10 f-i
D5	Control	6.19 ab	6.97 a-d	2.29 c-f	25.22 i	0.33 c-f	3.63 k
	NPK	6.43 ab	7.81 a-d	2.58 b-e	28.41 i	0.39 c	4.32 jk
	Compost	6.50 ab	8.80 abc	3.20 b	35.23 hi	0.51 ab	5.61 h-k
	NPK + Compost	6.63 ab	9.25 a	3.91 a	43.04 ghi	0.55 a	6.12 g-k

**Table 14. Interaction effect of density and fertilizer on some edible portion characteristics in Aquaban (2020-2021)**

Interaction Density × Fertilization	Length of edible portion (cm)	Dimeter of edible portion (mm)	Fresh weight of edible portion (g)	Total fresh weight of edible portion (g.m <sup>-1</sup> )	Dry weight of edible (g)	Total dry weight of edible (g.m <sup>-1</sup> )	
D1	Control	7.01 def	10.72 g	7.55 h	755.46 c	0.44 h	44.33 c
	NPK	7.26 b-f	15.39 def	11.15 e-h	1115.93 b	0.70 efg	70.66 b
	Compost	7.17 c-f	14.73 ef	10.27 fgh	1027.13 b	0.79 b-f	79.00 ab
	NPK + Compost	8.44 a	16.97 cde	15.10 bcd	1510.96 a	0.89 b-e	89.30 a
D2	Control	8.24 ab	15.09 def	10.55 e-h	469.13 de	0.69 efg	30.98 c-e
	NPK	8.50 a	15.40 def	13.94 c-f	619.71 cd	0.90 b-e	40.15 cd
	Compost	8.08 abc	15.50 def	10.46 e-h	455.18 de	0.77 def	34.26 cde
	NPK + Compost	7.63 a-e	13.53 fg	10.07 fgh	447.80 de	0.89 b-e	39.62 cd
D3	Control	7.08 c-f	11.06 g	8.30 gh	207.66 fg	0.56 fgh	14.04 gh
	NPK	6.93 ef	14.82 ef	10.85 e-h	271.26 efg	0.66 e-h	16.55 fgh
	Compost	7.24 b-f	21.66 a	14.21 b-e	355.37 efg	0.89 b-e	22.37 e-h
	NPK + Compost	8.28 ab	17.84 bcd	16.07 abc	401.90 def	1.03 abc	25.78 d-g
D4	Control	7.57 a-f	11.16 g	7.63 h	122.17 g	0.49 gh	7.98 h
	NPK	8.01 a-d	17.12 b-e	16.44 abc	263.18 efg	1.03 ab	16.62 fgh
	Compost	8.48 a	19.95 ab	19.42 a	310.85 efg	1.21 a	19.50 e-h
	NPK + Compost	8.29 ab	19.18 abc	16.33 abc	261.37 efg	1.01 a-d	16.28 fgh
D5	Control	6.53 f	15.87 def	11.41 d-h	125.55 g	0.78 c-f	8.59 h
	NPK	7.00 def	14.35 ef	11.79 d-g	129.70 g	0.83 b-e	9.13 h
	Compost	8.56 a	19.49 abc	17.99 ab	197.89 fg	1.24 a	13.74 gh
	NPK + Compost	8.58 a	19.09 abc	15.52 bc	170.77 fg	1.18 a	13.00 gh

\*The similar letters between treatments means there are no significant differences between them using Duncan's Multiple Test at 5% level.



**Table 15. Comparison between Grdarsha and Aquban under effect of different density and fertilizer on some edible portion characteristics in in the two studying seasons (2019-2020 and 2020-2021)**

Location	2020	2021	Tabled-t			
Parameters	Grdarsha	Aquban	Calculated-t	Grdarsha	Aquban	Calculated-t
Length of edible portion (cm)	5.98	6.57	-4.75	8.58	7.74	4.20
Dimeter of edible portion (mm)	6.78	7.27	-1.76	16.64	15.94	1.19
Fresh weight of edible portion (g)	1.87	2.21	-2.31	14.80	12.75	2.52
Total fresh weight of edible portion (g.m <sup>-2</sup> )	61.39	70.96	-1.11	543.95	461.45	1.08
Dry weight of edible (g)	0.32	0.33	-0.64	1.01	0.85	3.17
Total dry weight of edible (g.m <sup>-2</sup> )	11.03	11.42	-0.25	37.19	30.59	1.31

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