

## The influence of two broccoli hybrids, seedling age, and foliar application of garlic extract on quantitative and qualitative yield characteristics.

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### Abstract

The experiment was conducted during the agricultural seasons of 2021-2022 and 2022-2023 in the field belonging to the Agricultural Research Station at the University of Basra's College of Agriculture in Karima Ali (30.5616698 , 47.7517014). The objective was to study the effect of two broccoli hybrids (Matsuri and 2004), three seedling ages (30, 45, and 60 days), and five concentrations of garlic water extract (10, 20 mL L<sup>-1</sup> of local garlic variety and 10, 20 mL L<sup>-1</sup> of Chinese garlic variety), along with a control treatment (0). A total of 30 experimental treatments were implemented as a split-plot design with two replications using a complete randomized block design. Matsuri hybrid exhibited statistically significant superiority over the 2004 hybrid in total productivity and the percentage of nitrogen, phosphorus, and potassium in the leaves, as well as the chlorophyll content in the leaves for both seasons. Additionally, the 30-day-old seedling treatment showed significant superiority in the studied traits for both seasons. Furthermore, the foliar application treatment demonstrated superiority with increasing concentration, where the 20 mL L<sup>-1</sup> concentration of Chinese garlic extract significantly outperformed in all studied traits during both seasons.

**Keywords:** broccoli plant, hybrid, total productivity, garlic extract, seedling age, Qualitative attributes.

### Introduction:

Broccoli, scientifically known as *Brassica oleracea* var. *italica* Plenck, is a winter vegetable belonging to the Brassicaceae family. It is a herbaceous plant that morphologically resembles cauliflower and has been known for over 2700 years in the Mediterranean region of Asia Minor (9). However, it is one of the less commonly grown plants in Iraq. Broccoli is cultivated for its edible green flower heads, which are consumed as tender green florets along with their small, tender stems. It is considered one of the most valuable crops in this family in terms of nutritional value and is widely used for its therapeutic properties. Broccoli is rich

in various vitamins such as A, B1, B2, B6, B12, and essential minerals like calcium, sodium, potassium, manganese, zinc, and iron (16). The introduction of varieties and hybrids is an important method in the breeding and improvement of plants. It is an easy and rapid way to achieve desirable genetic traits, which can be tested under different environmental conditions of the importing country. Consequently, research centers can select varieties that are suitable for their specific environmental conditions (8). The response of vegetable crops to the transplanting process varies, with some crops showing successful transplanting tolerance. Broccoli is one such crop. One of the key determinants of

successful transplanting is the appropriate age at which seedlings are transferred to the field (11). The use of organic extracts, including garlic extract, has a positive impact on growth characteristics and yield. Garlic extract contains a high percentage of sulfur-containing amino acids like cysteine and methionine, which play essential roles in plant cellular processes. Additionally, it contains volatile oils like allicin, as well as vitamins and mineral elements (15).

#### **Materials and working methods:**

The experiment was conducted in the winter agricultural seasons of 2021-2022 and 2022-2023 at the Agricultural Research Station affiliated with the College of Agriculture at the University of Basra. Random soil samples were collected from the field at a depth of 0-30 cm. These samples were mixed thoroughly to determine certain physical and chemical properties in the central laboratory of the College of Agriculture at the University of Basra (Table 1). The field soil was plowed twice, cross plowed, leveled, and divided into three sections. Each section contained six rows, each with a length of 25 meters, a width of 0.5 meters, and a height of 15 cm. There was a 1-meter distance between each row. Each row was further divided into five experimental units, with each unit containing 10 plants, resulting in a total of 30 experimental units in each section. The

seedlings were planted with a spacing of 0.5 meters between each plant. Agricultural operations were carried out following the recommended practices for broccoli cultivation, and well-decomposed animal manure was added at a rate of 40 tons per hectare (11). The experiment included three factors for both seasons. These factors were two hybrids of broccoli plants (Matsuri and 2004), three seedling ages (30, 45, and 60 days), and garlic extract obtained from local garlic variety (Zubair garlic) and Chinese garlic (locally produced) at two concentrations for each (10 and 20 mL L<sup>-1</sup>). Additionally, there was a control treatment (0), which involved spraying with distilled water only. The spraying was done three times in the field, with a one-week interval between each spray, starting two weeks after transplanting. A Randomized Complete Block Design (R.C.B.D.) with a Split-Split Plot Design was used, where the hybrid was considered the main plot, seedling age the secondary plot, and spray concentrations with garlic extract were the sub-sub-plot. This resulted in a total of 30 factorial treatments, each with three replications, for a total of 90 experimental units. The statistical analysis of the results was conducted using Genstat, V. 10.3 (2011), and the Least Significant Differences Test (L.S.D.) was used to compare the means at a significance level of 0.05 (5).

**Table (1) shows some physical and chemical characteristics of field soil and irrigation water for the agricultural seasons 2021-2022 and 2022-2023.**

Soil properties		The first season 2021-2022	the second season 2022-2023
Degree of electrical conductivity (EC) (decisiemens m <sup>-1</sup> )		8.45	7.80
Soil acidity (pH)		7.61	7.43
dissolved ions (mmol l <sup>-1</sup> )	Na <sup>+</sup>	24.33	23.17
	Ca <sup>++</sup>	16.74	15.00
	Mg <sup>++</sup>	8.11	7.29
	SO <sub>4</sub> <sup>==</sup>	22.60	21.85
	Cl <sup>-</sup>	62.00	60.10
	HCO <sub>3</sub> <sup>-</sup>	3.1	2.90
Ready nitrogen	ppm	191	187
Ready phosphorus		74	72
Ready potassium		180	215
Organic matter (%)		0.65	0.74
Soil separations (%)			
sand		58.2	63.0
silt		10.0	10.6
clay		31.8	26.4
Soil texture		Sand mixture	Sand mixture
Irrigation water			
season	pH	Degree of electrical conductivity (decisiemens m <sup>-1</sup> )	
2022-2021	7.85	6.10	
2023-2022	7.80	5.34	

#### 1 - Total

**productivity** (tonnes per hectare): The total flower head yield (total harvest) was calculated as follows: Total plant yield (kg) × Plant density (17600 plants per hectare).

**2 - Chlorophyll Content Estimation in Leaves:** Chlorophyll content in flower heads was determined using the method described by (1). Chlorophyll was extracted using 80% acetone, and its concentration was measured

with a spectrophotometer at wavelengths of 663 and 645 nanometers. The chlorophyll content was calculated using the following equation: Total Chlorophyll (mg/L) = 20.2 × (645) D + 8.02 × (663) D, where D represents the device reading (optical density of the extracted chlorophyll).

The unit (mg/L) was then converted to (mg/100 g) using the following equation:

$\text{mg}/100 \text{ g} = (\text{mg}/\text{L}) \times 100 / (1000 \text{ mL}) \times \text{Sample weight (g)}.$

**3 - Nitrogen Percentage in Leaves:** Samples were digested according to (7) method, and the total nitrogen in the digested samples was determined using a Microkjeldhal steam distillation apparatus, following the Page et al. (1982) method.

**4 - Phosphorus Percentage in Leaves:** Phosphorus content was determined using the Ammonium Vanadomolybdate method for previously digested samples, as per (10). After the appearance of a yellow color, the intensity of the color in the solution was measured using a spectrophotometer at a wavelength of 470 nanometers.

**5 - Potassium Percentage in Leaves:** Potassium in the digested samples was determined using a Flame Photometer according to the (15) method.

### Results and discussion:

The table (2) shows the superiority of the hybrid in the trait of total plant yield, as the Matsuri hybrid surpassed the 2004 hybrid significantly in both seasons. It is also evident from the same table that the age of seedlings played a significant role in both seasons. The table also demonstrates that the spray treatment had a significant effect, with higher concentration sprays resulting in higher yields in both seasons. The table further indicates that in the first season, the pairwise interactions had a significant impact on the overall plant yield. Matsuri hybrid plants sprayed with a concentration of 20 ml per liter of Chinese garlic extract significantly outperformed the 2004 hybrid plants sprayed with a concentration of (0), with the highest and lowest values of the interaction factor being 18.28 and 9.36 tons per hectare, respectively, for both seasons. Additionally, 30-day-old

plants sprayed with a concentration of 20 ml per liter of Chinese garlic extract yielded significantly higher total yields, reaching 19.84 tons per hectare, compared to the lowest total yield of 8.93 tons per hectare for 60-day-old plants sprayed with (0) concentration. Regarding the pairwise and three-way interactions in the second season, the table shows that Matsuri hybrid plants sprayed with a concentration of 20 ml per liter of Chinese garlic extract outperformed the 2004 hybrid plants sprayed with (0) concentration, with a total yield of 20.45 tons per hectare compared to the lowest total yield of 10.83 tons per hectare for 2004 hybrid plants. Similarly, 30-day-old plants sprayed with a concentration of 20 ml per liter of Chinese garlic extract significantly outperformed 60-day-old plants sprayed with (0) concentration, with a total yield of 22.41 tons per hectare compared to the lowest total yield of 10.20 tons per hectare. Regarding the three-way interaction, the table shows that Matsuri hybrid plants planted at 30 days of age and sprayed with a concentration of 20 ml per liter of Chinese garlic extract significantly outperformed the 2004 hybrid plants planted at 60 days of age and sprayed with a concentration of 10 ml per liter of local garlic extract, with a total yield of 23.99 tons per hectare compared to the lowest total yield of 9.12 tons per hectare for the 2004 hybrid plants. Table (3) demonstrates the superiority of hybrid treatment, with the Matsuri hybrid outperforming the 2004 hybrid in the chlorophyll content of the leaves in both seasons. The treatment effect also showed that as the concentration of garlic extract increased, there was a significant increase in chlorophyll content for both seasons. In the first season, pairwise interactions gave a significant difference in this trait, with Matsuri

hybrid plants planted at 30 days of age significantly outperforming 60-day-old 2004 hybrid plants, yielding 6.09 mg/100g fresh weight compared to the lowest value of 4.04 mg/100g fresh weight. Similarly, Matsuri hybrid plants sprayed with a concentration of 20 ml per liter of Chinese garlic extract significantly outperformed 2004 hybrid plants sprayed with (0) concentration, with chlorophyll content in the leaves reaching 7.01 and 3.29 mg/100g fresh weight, respectively, for both treatments. Additionally, 30-day-old plants sprayed with a concentration of 20 ml per liter of Chinese garlic extract significantly outperformed 60-day-old plants sprayed with (0) concentration, with chlorophyll content reaching 7.04 and 3.61 mg/100g fresh weight, respectively. There was no significant three-way interaction effect in the first season. The table also indicates that the interaction between the hybrid and age had a significant effect on this trait. Matsuri hybrid plants planted at 30 days of age significantly outperformed 45-day-old 2004 hybrid plants, yielding 5.84 mg/100g fresh weight compared to the lowest value of 4.34 mg/100g fresh weight. Similarly, 30-day-old plants sprayed with a concentration of 20 ml per liter of Chinese garlic extract significantly outperformed 60-day-old plants sprayed with (0) concentration, with chlorophyll content reaching 6.95 and 3.58 mg/100g fresh weight, respectively. The remaining interactions did not have a significant effect on this trait. Table (4) shows the statistical superiority of the Matsuri hybrid over the 2004 hybrid for both seasons. It also indicates that the age of seedlings had a significant effect on both seasons. Moreover, the table demonstrates the significant effect of the spray treatment with increasing concentration for both seasons, except for the 10 ml per liter local garlic

extract concentration, which did not outperform the comparison treatment in the first season.

In the first season, the interaction between Matsuri hybrid plants planted at 30 days of age showed a significant difference. They gave the highest percentage of nitrogen in the leaves, which reached 3.00%, compared to the lowest percentage of 2.50% for the 60-day-old 2004 hybrid plants. Additionally, 30-day-old plants that were sprayed with a concentration of 20 ml per liter of Chinese garlic extract significantly outperformed 60-day-old plants, yielding the highest percentage of 3.39% compared to the lowest percentage of 2.11% for 60-day-old plants sprayed with (0) concentration. The other interactions did not have a significant effect.

In the second season, pairwise interactions had a significant effect, except for the three-way interaction. Matsuri hybrid plants planted at 30 days of age significantly outperformed 60-day-old plants, with the highest nitrogen percentage of 3.12% compared to the lowest percentage of 2.59% for 60-day-old 2004 hybrid plants. Similarly, Matsuri hybrid plants sprayed with a concentration of 20 ml per liter of Chinese garlic extract significantly outperformed those sprayed with (0) concentration, with a nitrogen percentage of 3.36% compared to 2.24% for the 2004 hybrid plants. Additionally, 30-day-old plants sprayed with a concentration of 20 ml per liter of Chinese garlic extract yielded the highest nitrogen percentage of 3.50% compared to the lowest percentage of 2.13% for 60-day-old plants sprayed with (0) concentration. Table (5) shows the statistical superiority of the Matsuri hybrid over the 2004 hybrid for both seasons. It also indicates the significant effect of the age of seedlings on the percentage of nitrogen, except for the 60-day-old age, which

did not outperform the 45-day-old age for both seasons. In terms of the spray treatment, it had a significant effect with increasing concentrations for both seasons. In the first season, pairwise and three-way interactions had a significant effect, except for the interaction between the hybrid and age. Matsuri hybrid plants sprayed with a concentration of 20 ml per liter of Chinese garlic extract significantly outperformed the 10 ml per liter local garlic extract concentration, with the highest phosphorus percentage of 1.573% compared to 0.909% for the 2004 hybrid plants. Similarly, 30-day-old plants sprayed with a concentration of 20 ml per liter of Chinese garlic extract significantly outperformed those sprayed with (0) concentration, with a phosphorus percentage of 1.976% compared to 0.902% for 60-day-old plants. The three-way interaction between Matsuri hybrid plants planted at 60 days of age and sprayed with a concentration of 20 ml per liter of Chinese garlic extract outperformed significantly, yielding a phosphorus percentage of 0.310% compared to 0.122% for 45-day-old Matsuri hybrid plants sprayed with (0) concentration. In the second season, all pairwise interactions were significant, except for the three-way interaction. The 2004 hybrid plants planted at 60 days of age significantly outperformed those planted at 45 days of age, with a phosphorus percentage of 0.224% compared to 0.199%. Similarly, Matsuri hybrid plants sprayed with a concentration of 20 ml per liter of Chinese garlic extract significantly outperformed those sprayed with 10 ml per liter of local garlic extract, yielding a phosphorus percentage of 0.309% compared to 0.160%. Additionally, 30-day-old plants sprayed with a concentration of 20 ml per liter of Chinese garlic extract significantly

outperformed those sprayed with (0) concentration, with a phosphorus percentage of 0.314% compared to 0.127%. As for the three-way interaction, Matsuri hybrid plants planted at 30 days of age and sprayed with a concentration of 20 ml per liter of Chinese garlic extract outperformed significantly, yielding a phosphorus percentage of 2.228% compared to 0.862% for 60-day-old Matsuri hybrid plants sprayed with 10 ml per liter of local garlic extract. Table (6) demonstrates the significant statistical superiority of the Matsuri hybrid in the percentage of potassium concentration in the leaves over the 2004 hybrid for both seasons. It also highlights the superiority of the seedling age treatment as it increased, except for the 60-day age, which did not surpass the comparison treatment in the first season. The table illustrates the superiority of the pairwise and three-way interactions in the first season, except for the interaction between the hybrid and the age of seedlings. Matsuri hybrid plants, when sprayed with a concentration of 20 ml per liter of Chinese garlic extract, significantly outperformed those sprayed with 10 ml per liter of local garlic extract, with the highest potassium percentage reaching 1.573% compared to the lowest percentage of 0.909% for the 2004 hybrid plants. Similarly, 30-day-old plants that were sprayed with a concentration of 20 ml per liter of Chinese garlic extract significantly outperformed 60-day-old plants sprayed with (0) concentration, with a potassium percentage of 1.976% compared to 0.902%. Furthermore, 30-day-old plants sprayed with a concentration of 20 ml per liter of Chinese garlic extract significantly outperformed 45-day-old plants sprayed with 10 ml per liter of local garlic extract, yielding a potassium percentage of 2.121% compared to 0.840%. In the second season, the table

shows the superiority of all pairwise and three-way interactions. It demonstrates that Matsuri hybrid plants planted at 30 days of age yielded significantly higher results, with a potassium percentage of 1.481% compared to 0.977% for 60-day-old 2004 hybrid plants. Additionally, Matsuri hybrid plants sprayed with a concentration of 20 ml per liter of Chinese garlic extract significantly outperformed those sprayed with (0) concentration, with a potassium percentage of 1.630% compared to 0.914%. Furthermore, 30-day-old plants sprayed with a concentration of 20 ml per liter of Chinese garlic extract significantly outperformed 60-day-old plants sprayed with 10 ml per liter of local garlic extract, yielding a potassium percentage of 2.094% compared to 0.908%. As for the three-way interaction, the table demonstrates the significant superiority of Matsuri hybrid plants planted at 30 days of age and sprayed with a concentration of 20 ml per liter of Chinese garlic extract, yielding the highest potassium percentage of 2.228% compared to the lowest percentage of 0.862% for 60-day-old 2004 hybrid plants sprayed with 10 ml per liter of local garlic extract. The tables (2, 3, 4, 5, 6) demonstrate the significant statistical superiority of the Matsuri hybrid in overall productivity and the percentage of nitrogen, phosphorus, potassium, as well as the chlorophyll content in the leaves. This superiority can be attributed to the genetic

differences among the hybrids and the extent to which the Matsuri hybrid responds to prevailing environmental conditions. These findings align with the research of (13) and (14). The same tables also highlight the Matsuri hybrid's superiority in the percentage of nitrogen, phosphorus, and potassium in the leaves. This is also attributed to the genetic variations among the hybrids. Furthermore, the superiority of the 30-day-old age in the mentioned traits, except for the element P% where 60-day-old plants excelled, is attributed to the plants' ability at this age to absorb nutrients efficiently and increase their chlorophyll content. These conditions are favorable for the overall productivity of broccoli plants, and they are influenced by the warm weather in the early stages of plant growth followed by a decrease in temperature during the formation of the flower head. These conditions are ideal for the growth and productivity of broccoli plants and are in line with the results of (18), (14), and (2). Furthermore, the superiority of the treatment with 20 ml per liter of Chinese garlic extract in the mentioned traits is attributed to the extract's high concentrations of sulfur, nutrients, and vitamin C. These compounds contribute to the treatment's superiority in the mentioned traits. These findings align with the research of (4), (11), (3), and (6).

**Table (2) Effect of two broccoli hybrids, seedling age, and spraying with garlic extract and their interactions on total productivity (ton hectare - 1 ) for the seasons 2021-2022 and 2022-2023**

first season								the second season							
Hybrid	Seedling age (day)	Spraying with garlic extract (ml <sup>1</sup> - liter)					Hybrid × the age	Hybrid	Seedling age (day)	Spraying with garlic extract (ml <sup>1</sup> - liter)					Hybrid × the age
		Comparison	Garlic local		Garlic Chinese					Comparison	Garlic local		Garlic Chinese		
		0	10	20	10	20				0	10	20	10	20	
Matsuri	30	11.09	12.62	14.87	17.97	21.56	15.62	Matsuri	30	12.56	12.28	16.88	20.61	23.99	17.26
	45	10.18	11.66	13.51	15.18	17.26	13.56		45	11.73	12.94	12.82	16.71	20.45	14.93
	60	9.69	10.72	12.05	14.06	16.01	12.51		60	10.74	11.28	11.44	17.96	16.92	13.67
2004	30	10.17	11.66	13.82	16.28	18.12	14.01	2004	30	11.72	12.85	12.8	17.74	20.83	15.19
	45	9.73	10.51	11.92	12.67	14.79	11.92		45	10.79	12.01	13.36	13.82	16.51	13.3
	60	8.18	9.61	10.44	12.13	13.12	10.69		60	9.96	9.12	11.29	12.75	14.47	11.52
RLSD 0.05		NS					NS	NS		1.12					NS
Hybrid × Spraying							Average of hybrid	Hybrid × Spraying							Average of hybrid
Hybrid	Matsuri	10.32	11.67	13.47	15.73	18.28	13.89	Hybrid	Matsuri	11.68	12.17	13.71	18.42	20.45	15.29
	2004	9.36	10.59	12.06	13.69	15.34	12.21		2004	10.83	11.33	12.48	14.77	17.27	13.34
RLSD 0.05		0.55					0.54	RLSD 0.05		0.66					0.58
the age × Spraying							Average of age	the age × Spraying							Average of age
The age	30	10.63	12.14	14.34	17.12	19.84	14.81	The age	30	12.14	12.57	14.84	19.18	22.41	16.23
	45	9.96	11.09	12.71	13.92	16.02	12.74		45	11.26	12.47	13.09	15.27	18.48	14.11
	60	8.93	10.16	11.25	13.1	14.56	11.6		60	10.35	10.2	11.37	15.35	15.69	12.59
RLSD 0.05		0.67					0.40	RLSD 0.05		0.79					0.38
Average of spray		9.84	11.13	12.77	14.71	16.81		Average of spray		11.25	11.75	13.1	16.6	18.86	
RLSD 0.05		0.37						RLSD 0.05		0.46					



**Table ( 3 ) Effect of two hybrids of broccoli, seedling age, spraying with garlic extract, and their interactions on the chlorophyll content of the leaves (mg 100g - 1 fresh weight) ( for the seasons 2022-2021 and 2022-2023 .**

first season								the second season							
Hybrid	Seedling age (day)	Spraying with garlic extract (ml <sup>1</sup> - liter)					Hybrid × the age	Hybrid	Seedling age (day)	Spraying with garlic extract (ml <sup>1</sup> - liter)					Hybrid × the age
		Comparison	Garlic local		Garlic Chinese					Comparison	Garlic local		Garlic Chinese		
			0	10	20	10					20	0	10	20	
Matsuri	30	4.64	5.27	5.45	6.64	8.47	6.09	Matsuri	30	4.67	5.41	4.8	6.72	7.6	5.84
	45	4.42	4.88	5.2	5.91	6.51	5.38		45	3.92	4.76	5.89	6.39	6.93	5.58
	60	4.18	4.71	5	5.66	6.05	5.12		60	3.7	4.51	4.91	5.77	6.29	5.03
2004	30	3.45	3.82	4.2	4.95	5.61	4.4	2004	30	3.49	3.89	4.35	5.22	6.3	4.65
	45	3.39	3.71	4.05	4.83	4.91	4.18		45	3.62	3.67	4.09	4.92	5.41	4.34
	60	3.05	3.62	3.96	4.54	5.05	4.04		60	3.46	3.97	4.47	5.32	5.28	4.50
RLSD 0.05		NS					0.25	NS		NS					0.18
Hybrid × Spraying							Average of hybrid	Hybrid × Spraying							Average of hybrid
Hybrid	Matsuri	4.41	4.95	5.21	6.07	7.01	13.89	Hybrid	Matsuri	4.09	4.89	5.2	6.29	6.94	5.48
	2004	3.29	3.71	4.07	4.77	5.19	12.21		2004	3.52	3.84	4.3	5.15	5.66	4.50
RLSD 0.05		0.31					0.29	RLSD 0.05		NS					0.19
the age × Spraying							Average of age	the age × Spraying							Average of age
The age	30	4.04	4.54	4.82	5.8	7.04	5.25	The age	30	4.08	4.65	4.57	5.97	6.95	5.24
	45	3.9	4.29	4.62	5.37	5.71	4.78		45	3.77	4.21	4.99	5.65	6.17	4.96
	60	3.61	4.16	4.48	5.1	5.55	4.58		60	3.58	4.24	4.69	5.55	5.78	4.77
RLSD 0.05		0.37					0.17	RLSD 0.05		0.45					0.13
Average of spray		3.85	4.33	4.64	5.42	6.1		Average of spray		3.81	4.37	4.75	5.72	6.30	
RLSD 0.05		0.22						RLSD 0.05		0.28					

**Table ( 4 ) Effect of two broccoli hybrids, seedling age, spraying with garlic extract, and their interactions on the percentage of nitrogen in the leaves for the seasons 2021-2022 and 2022-2023.**

first season								the second season							
Hybrid	Seedling age (day)	Spraying with garlic extract (ml <sup>l</sup> - liter)					Hybrid × the age	Hybrid	Seedling age (day)	Spraying with garlic extract (ml <sup>l</sup> - liter)					Hybrid × the age
		Comparison	Garlic local		Garlic Chinese					Comparison	Garlic local		Garlic Chinese		
			0	10	20	10					20	0	10	20	
Matsuri	30	2.51	2.67	3.07	3.17	3.58	3.00	Matsuri	30	2.70	2.64	3.19	3.41	3.65	3.12
	45	2.29	2.6	2.81	2.98	3.14	2.76		45	2.22	2.73	2.96	3.08	3.33	2.86
	60	2.11	2.37	2.54	2.83	3.00	2.57		60	2.08	2.28	2.66	2.91	3.11	2.61
2004	30	2.28	2.49	2.67	3.00	3.21	2.73	2004	30	2.35	2.58	2.74	3.1	3.36	2.82
	45	2.25	2.33	2.61	2.82	3.01	2.60		45	2.2	2.41	2.77	2.93	3.12	2.68
	60	2.11	2.25	2.37	2.8	2.97	2.50		60	2.19	2.38	2.44	2.90	3.04	2.59
RLSD 0.05		NS					0.05	NS		NS					0.05
Hybrid × Spraying							Average of hybrid	Hybrid × Spraying							Average of hybrid
Hybrid	Matsuri	2.30	2.54	2.81	2.99	3.24	2.78	Hybrid	Matsuri	2.33	2.55	2.94	3.13	3.36	2.86
	2004	2.21	2.35	2.55	2.87	3.06	2.61		2004	2.24	2.45	2.65	2.97	3.17	2.70
RLSD 0.05		NS					0.04	RLSD 0.05		0.09					0.06
the age × Spraying							Average of age	the age × Spraying							Average of age
The age	30	2.39	2.58	2.87	3.08	3.39	2.86	The age	30	2.52	2.61	2.96	3.25	3.5	2.97
	45	2.27	2.46	2.71	2.9	3.07	2.68		45	2.21	2.57	2.86	3	3.22	2.77
	60	2.11	2.31	2.45	2.81	2.98	2.53		60	2.13	2.33	2.55	2.9	3.07	2.60
RLSD 0.05		0.09					0.04	RLSD 0.05		0.11					0.03
Average of spray		2.26	2.45	2.68c	2.93	3.15		Average of spray		2.29	2.5	2.79	3.05	3.27	
RLSD 0.05		0.05						RLSD 0.05		0.07					

Table ( 5 ) Effect of two broccoli hybrids, seedling age, spraying with garlic extract, and their interactions on the percentage of phosphorus in the leaves for the seasons 2021-2022 and 2022-2023

first season								the second season							
Hybrid	Seedling age (day)	Spraying with garlic extract (ml <sup>1-</sup> liter)					Hybrid × the age	Hybrid	Seedling age (day)	Spraying with garlic extract (ml <sup>1-</sup> liter)					Hybrid × the age
		Comparison	Garlic local		Garlic Chinese					Comparison	Garlic local		Garlic Chinese		
			0	10	20	10					20	0	10	20	
Matsuri	30	0.127	0.167	0.191	0.235	0.295	0.203	Matsuri	30	0.133	0.172	0.186	0.247	0.301	0.207
	45	0.122	0.182	0.211	0.275	0.305	0.219		45	0.129	0.173	0.22	0.283	0.311	0.223
	60	0.124	0.127	0.19	0.29	0.31	0.208		60	0.122	0.135	0.202	0.287	0.317	0.213
2004	30	0.131	0.154	0.182	0.196	0.22	0.176	2004	30	0.128	0.167	0.178	0.207	0.232	0.182
	45	0.13	0.166	0.198	0.225	0.261	0.196		45	0.134	0.174	0.19	0.219	0.28	0.199
	60	0.137	0.175	0.215	0.257	0.294	0.215		60	0.132	0.191	0.224	0.262	0.311	0.224
RLSD 0.05		0.02					0.014	NS		NS					0.016
Hybrid × Spraying							Average of hybrid	Hybrid × Spraying							Average of hybrid
Hybrid	Matsuri	0.124	0.158	0.197	0.266	0.303	0.210	Hybrid	Matsuri	0.128	0.16	0.203	0.272	0.309	0.214
	2004	0.132	0.165	0.198	0.226	0.258	0.196		2004	0.131	0.177	0.197	0.229	0.274	0.202
RLSD 0.05		0.009					0.004	RLSD 0.05		0.012					0.009
the age × Spraying							Average of age	the age × Spraying							Average of age
The age	30	0.129	0.16	0.186	0.215	0.257	0.189	The age	30	0.130	0.169	0.182	0.227	0.266	0.195
	45	0.126	0.174	0.204	0.25	0.283	0.207		45	0.132	0.173	0.205	0.251	0.295	0.211
	60	0.131	0.151	0.203	0.273	0.302	0.212		60	0.127	0.163	0.213	0.274	0.314	0.218
RLSD 0.05		0.015					0.012	RLSD 0.05		0.019					0.013
Average of spray		0.128	0.162	0.198	0.246	0.280		Average of spray		0.130	0.168	0.2	0.251	0.292	
RLSD 0.05		0.007						RLSD 0.05		0.009					

Table ( 6 ) Effect of two broccoli hybrids, seedling age, spraying with garlic extract, and their interactions on the percentage of potassium in the leaves for the seasons 2021-2022 and 2022-2023

first season								the second season							
Hybrid	Seedling age (day)	Spraying with garlic extract (ml <sup>l</sup> - liter )					Hybrid × the age	Hybrid	Seedling age (day)	Spraying with garlic extract (ml <sup>l</sup> - liter )					Hybrid × the age
		Comparison	Garlic local		Garlic Chinese					Comparison	Garlic local		Garlic Chinese		
			0	10	20	10					20	0	10	20	
Matsuri	30	0.940	0.988	1.371	1.81	2.121	1.446	Matsuri	30	0.951	1.048	1.314	1.865	2.228	1.481
	45	0.931	0.969	1.011	1.162	1.326	1.08		45	0.892	1.01	1.069	1.22	1.406	1.119
	60	0.914	0.93	0.98	1.03	1.273	1.025		60	0.9	0.954	1.019	1.006	1.258	1.027
2004	30	0.935	0.978	1.26	1.76	1.83	1.352	2004	30	0.921	1.018	1.277	1.804	1.959	1.396
	45	0.91	0.84	0.962	1.017	1.186	0.983		45	0.941	0.883	1.072	1.006	1.245	1.029
	60	0.89	0.91	0.955	0.981	1.02	0.951		60	0.93	0.862	0.981	1.009	1.103	0.977
RLSD 0.05		0.062					NS	NS	0.08					0.029	
Hybrid × Spraying							Average of hybrid	Hybrid × Spraying							Average of hybrid
Hybrid	Matsuri	0.928	0.962	1.12	1.334	1.573	1.183	Hybrid	Matsuri	0.914	1.004	1.134	1.363	1.63	1.209
	2004	0.912	0.909	1.059	1.252	1.345	1.095		2004	0.931	0.921	1.11	1.273	1.436	1.134
RLSD 0.05		0.04					0.042	RLSD 0.05		0.048					0.038
the age × Spraying							Average of age	the age × Spraying							Average of age
The age	30	0.937	0.983	1.315	1.785	1.976	1.399	The age	30	0.936	1.033	1.295	1.834	2.094	1.438
	45	0.921	0.904	0.986	1.089	1.256	1.031		45	0.917	0.946	1.071	1.113	1.325	1.074
	60	0.902	0.92	0.967	1.005	1.146	0.988		60	0.915	0.908	1	1.007	1.18	1.002
RLSD 0.05		0.042					0.011	RLSD 0.05		0.055					0.015
Average of spray		0.92	0.936	1.089	1.293	1.459		Average of spray		0.922	0.962	1.122	1.318	1.533	
RLSD 0.05		0.026						RLSD 0.05		0.035					

**Conclusions and Recommendations:****Conclusions**

1- The Matsuri hybrid excelled in the plant's vegetative growth indicators and this was reflected positively on the yield characteristics.

2- The results showed that the seedling age of 30 days led to an increase in most of the studied traits.

3- Spraying broccoli plants with Chinese garlic extract at a concentration of 20 ml l<sup>-1</sup> improved vegetative growth indicators, which reflected positively on yield indicators and its components.

**Recommendations**

Cultivation of the Matsuri hybrid, as it excelled in most quantitative and qualitative characteristics compared to the 2004 hybrid.

To obtain the best growth of plants as well as high productivity, it is preferable to plant seedlings at the age of 30 days, as seedlings at this age have advantages in terms of their tolerance to the transplantation process and the speed of resuming their growth in the field compared to the ages (45 and 60 days). To obtain a high productivity of broccoli plants, we recommend applying concentrations of Chinese garlic extract higher than 20 ml L<sup>-1</sup> two weeks after transplanting three times, with a week between one application and another.

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