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Influence of Planting Date and Foliar Application of Marine-Fert on the Growth, Yield, and Nutrient Content of Three Broccoli Hybrids (Brassica oleracea L. var. italica) Under Plastic House Conditions

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ABSTRACT
The experiment was conducted during the fall season of 2024 and extended until March 2025 inside a 500 m² plastic house located at Malta Nursery, which is affiliated with the Directorate of Horticulture in Duhok City, Kurdistan Region, Iraq. The main objective of this study was to evaluate the impact of two planting dates (September 15 and October 1), three broccoli hybrids (Batavia, Covina, and Lucky), and three concentrations of seaweed extract (Marine-Fert) (0, 1, and 2 ml/L) on various parameters of broccoli, including vegetative growth, yield performance, and nutrient content under protected cultivation conditions. Foliar spraying of the Marine-Fert seaweed extract was carried out three times throughout the growing season. The first (6.10%). In contrast, the first planting date (September 15) resulted in a higher lateral floret yield (494.59 g/plant) and nitrogen content (2.28%). Among the three hybrids, 'Lucky' exhibited superior performance, recording the highest values for main head weight (1029.17 g/head), lateral floret yield foliar application began 15 days after transplanting, and the following sprays were applied at 15-day intervals. The aim was to monitor how these treatments influenced the physiological and productive traits of the broccoli plants. The findings demonstrated that the second planting date (October 1) significantly enhanced the main head weight (978.44 g/head), phosphorus content (0.526%), and potassium content (520.33 g/plant), total yield (38.74 tons/hectare), and nitrogen content (2.28%). Moreover, the foliar application of Marine-Fert at 2 ml/L yielded the best outcomes in terms of growth and productivity. These results highlight the critical role of optimized planting time, hybrid selection, and foliar nutrition in improving broccoli production under plastic house conditions.

***Keywords*:** Planting date, Broccoli, Hybrids, Seaweed extract, Growth, Yield.

INTRODUCTION

Broccoli (Brassica oleracea var. italica), a nutrient-dense vegetable belonging to the Brassicaceae family, is renowned for its high nutritional value and numerous health benefits. Originating from the Mediterranean region, where it has been cultivated for thousands of years, broccoli eventually spread across Europe and more recently reached countries such as Iraq [1, 2]. It is rich in essential nutrients including vitamin C, vitamin K, dietary fiber, glucosinolates, and phenolic compounds, which collectively contribute to the prevention of various diseases such as cancer, cardiovascular conditions, and metabolic disorders [3, 4]. As a cool-season crop, broccoli thrives best at temperatures between 18–24°C, requiring moderate moisture and 6–8 hours of direct sunlight daily for optimal growth. It tolerates light frost, making it suitable for cultivation in early spring and fall, especially during its vegetative and head formation stages, provided environmental conditions remain cool and stable.

Planting dates play a crucial role in successful broccoli cultivation, as its yield and nutritional characteristics are influenced by environmental factors such as temperature, humidity, and solar radiation. Studies have shown that growing broccoli in cooler seasons improves head quality and reduces the risk of premature flowering, leading to a more resilient and high-quality crop [5].

One of the most important agricultural operations that increase the productivity of broccoli is the cultivation of this crop at different dates during the same season in order to prolong its availability in the market. This can be achieved through successive planting, i.e., cultivating the same variety or different cultivars at various dates during the same growing season, with an emphasis on early cultivation [6].

Many researchers have studied the effect of planting dates on broccoli. One study examined three planting dates (1st September, 1st October, and 1st November) and found that the second planting date (1st October) led to significant improvements in both yield-related traits and vegetative growth characteristics. Specifically, the 1st October planting produced the highest values for main head weight and total head yield per plot and per feddan [7].

In a study conducted under desert conditions in southern Iraq, planting broccoli on 1st September combined with phosphate fertilization at 800 kg ha^{-1} resulted in the highest values for yield components, including main and lateral curd weights, curd diameter, total yield per plant (0.789 kg), and total productivity (17.36 t ha^{-1}). In addition to yield traits, this treatment also enhanced the nutritional composition of broccoli heads by recording the highest levels of nitrogen (N), phosphorus (P), potassium (K), chlorophyll, vitamin C, total soluble solids, and carbohydrates [8].

Together, these findings emphasize that optimal planting date—October 1st in Egyptian conditions and September 1st under Iraqi desert conditions—combined with appropriate cultivar and fertilization strategy, can significantly enhance both quantitative yield and nutrient accumulation in broccoli.

Seaweed extracts are categorized as significant biostimulants derived from marine algae. They are widely used in agriculture because of their rich content of bioactive compounds, including betaines and betaine-like compounds (N-containing), polysaccharides, sterols, nutrients, and valuable plant growth hormones such as auxins, cytokinins, gibberellins, and brassinosteroids [9, 10]. When applied at low concentrations, seaweed extracts have proven superior in improving crop yield and plant resistance to environmental stress [11, 12, 13]. In one study, applying fulvic acid at 2.5 g L^{-1} and seaweed extract at 6 mL L^{-1} to broccoli plants significantly enhanced yield traits such as total yield and flower head weight compared to other treatments [14]. Another study reported that foliar spraying of broccoli with biostimulants (seaweed extract at 3 mL/L + Jeevamrut 3%) significantly improved plant height, number of leaves, leaf width and length, stem diameter, number of branches, and leaf area compared to untreated plants [15]. Further results revealed the best harvest characteristics—such as number and weight of lateral heads, overall plant yield, and marketable yield—were achieved with foliar applications of seaweed extract and bio-cozyme at 2 mL L^{-1} [16].

The aim of this study is to optimize broccoli production by identifying the best planting date, hybrid, and foliar application strategies—specifically using Marine-Fert at different levels—to enhance growth, yield, and nutritional quality under plastic house conditions in Duhok province, while promoting environmental sustainability through the use of seaweed-based fertilizers.

Materials and Methods

The experiment was conducted during the fall of 2024 and winter of 2025 at the Malta Directorate Horticulture Nursery in Dohuk, Kurdistan Region, Iraq, within a 500 m² plastic house situated in a Mediterranean climate characterized by hot, dry summers and cold winters. Initially, the soil was fertilized with 2 tons of decomposed sheep manure to improve fertility, followed by plowing in July 2024, leveling in September, and covering with new plastic sheeting to enhance light efficiency. A drip irrigation system was installed, consisting of main pipes (3-inch diameter, 9 m long) and secondary pipes (16 mm diameter) with drippers spaced every 40 cm to ensure efficient watering. Broccoli seeds were sown in plastic trays containing 50 holes (70 ml each) filled with peat moss on two dates: August 15 and September 1, 2024. The seedlings were grown inside a shaded house with 70% shading to protect them from the high summer temperatures reaching 45°C and were transplanted into the field after reaching the four true leaf stage on September 15 and October 1, 2024. The planting layout involved two rows per replicate with a spacing of 40 × 70 cm between plants within each row, arranged in a randomized complete block design (RCBD) with a split-split plot arrangement, encompassing 18 treatments with three replications.

The main factors included planting date (September 15 and October 1), the secondary factors were three broccoli hybrids (Batavia F1, Covina F1, Lucky F1), and the sub-factor involved three levels of seaweed extract fertilization (0, 1, and 2 mL L^{-1}). Seaweed extract (Marine-Fert), derived from *Ascophyllum nodosum*, was applied three times at 15-day intervals during October and November 2024 using a low-pressure sprayer, containing approximately 400 ppm of kinetin (cytokinin), 20–22% organic matter, and various nutrients, micronutrients, growth regulators, vitamins, sugars, and organic acids. Standard agronomic practices, including irrigation as needed, weed removal, and soil ridging around seedlings, were maintained throughout the growing period. Data collected from the experiment were analyzed using SAS software, and treatment means were compared using Duncan's Multiple Range Test (DMRT) at $P \leq 0.05$ to determine significant differences among treatments.

The following parameters were recorded at the end of the experiment:

Yield CharacteristicsThe average weight of the main flower head (g/head) was measured according to [17]. The yield of side flower heads per plant (g/plant) was determined based on the method described in [18]. The total yield per hectare, including both main and side flower heads (tons/ha), was calculated following [19].

Concentration of Minerals and Nutrients in the Curd

The nitrogen content (%) in the curd was measured according to the procedure outlined in [20], while phosphorus (%) concentration was determined following the method in [21]. Potassium (%) content was assessed using the technique described in [22].

Results and Discussion

1.Yield Characteristics

Average Weight of the Main Flower Head (g/head).

Table (1) effect of planting date, hybrids, and foliar application of Marine-Fert, and their interactions on Average weight of the main flower head (g/head)

Date Planting	Hybrid	Marine-Fert (mL L^{-1}) 0	1	2	Date *Hybrid	Effect of Date Planting
15-Sep	Batavia	888.77 b-d	892.84 b-d	904.29 b-d	895.30 b	882.94 b
	Covina	673.83 e	768.41 de	840.71 cd	760.98 c	
	lucky	948.47 a-d	959.63 a-c	1069.56 ab	992.55 ab	
1-Oct	Batavia	963.33 a-c	954.67 a-c	974.00 a-c	964.00 b	978.44 a
	Covina	847.33 cd	983.00 a-c	886.33 b-d	905.56 b	
	lucky	992.67 a-c	1095.33 a	1109.33 a	1065.78 a	
Date* Marine – Fert	15-Sep	837.02 c	873.63 bc	938.18 ab		
	1-Oct	934.44 ab	1011.00 a	989.89 a	Effect of Hybrid	
Marine Fert *Hybrid	Batavia	926.05 bc	923.75 bc	939.14 bc	929.65 b	
	Covina	760.58 d	875.71 cd	863.52 cd	833.27 c	
	lucky	970.57 bc	1027.48 ab	1089.45 a	1029.17 a	
Effect of Marine Fert		885.73 b	942.31 ab	964.04 a		

Values with the same letter in the column, row, or interactions are not significantly different according to Duncan's test at the 0.05 level.

The results in Table 1 showed that planting date, hybrid type, Marine-Fert foliar application, and their interactions had significant effects on the average weight of the main flower head. The second planting date recorded a significantly increased head weight to 978.44 g/head when compared to the first date reached to 882.94 g/head. Among the type of hybrids plant, the type of Lucky was significantly outperformed on Batavia type to 929.65 g/head and Covina to 833.27g/head with the highest average head weight reached to 1029.17g/head. However, foliar application of Marine-Fert had a significantly increased head weight to 964.04 g/head with the highest dose 2 mL L^{-1} which followed by the 1 mL L^{-1} reached to 942.31 g/head, and the control 885.73 g/head.

The interaction between date of planting and hybrid type, the second planting with Lucky type 1065.78 g, while the lowest was for first planting date Covina to 760.58 g/head. Additionally, the highest value 1089.45 g/head of head weight was recorded for plants that sprayed with Marine Fert at 2 mL L^{-1} and lucky type when compared with low value 760.58 g/head for 0 mL L^{-1} Marine Fert interacted with Covina type. The third interaction between date, and Marine Fert indicated that the head weight was significantly increased which reached to 989.89 g/head for the second date interacted with 2 mL L^{-1} Marine Fert respectively, compared with low head weight to 837.02 g/head for the plants first date and non treated with Marine Fert.

The triple interaction among the date of planting, hybrid type and Marine-Fert clarified that the plants which second date, lucky type and interacted with 2 mL L^{-1} Marine-Fert gave the highest significant values 1109.33g/head and of head weight respectively, compared with the least value 673.83 g/head for the plants first date, Covina type and sprayed with 0 mL L^{-1} Marine-Fert.

Yield of Side Flower Heads per Plant (g/plant).

The results in Table 2 indicated that the first planting date significantly increased the yield of side flower heads to 494.59 g/plant compared to the second date which reached to 349.66 g/plant. However, the type of Lucky was significantly outperformed on Batavia type to 393.55 g/plant and Covina to 352.51g /plant with the highest average head weight reached to 520.33 g/plant. However, foliar application of Marine-Fert had a significantly increased yield of side flower heads to 446.26 g with the highest dose 2 mL L^{-1} which followed by the 1 mL L^{-1} treached to 406.30 g/plant, and the control 413.83 g/plant.

The interaction between date of planting and hybrid type of plant, the first date of planting and intracted with Lucky type was significantly increased yield of side flower heads reached to 528.32 g/plant, respectivly, with the lowest was for second date of planting and Batavia type wich reached 224.19 g/plant.

Table (2) illustrates the effect of planting date, hybrids, and foliar application of Marine-Fert, and their interactions on Yield of side flower heads per plant (g/plant (

Date Planting	Hybrid	Marine-Fert (mL L^{-1}) 0	1	2	Date *Hybrid	Effect of Date Planting
15-Sep	Batavia	431.39 de	518.41 a-c	492.67 cd	480.82 b	494.59 a
	Covina	513.00 bc	454.52 cd	456.37 cd	474.63 b	
	lucky	502.04 cd	499.35 cd	583.57 a	528.32 a	
1-Oct	Batavia	183.34 g	240.54 g	248.70 g	224.19 d	349.66 b
	Covina	380.68 ef	239.50 g	317.23 f	312.47 c	
	lucky	472.51 cd	485.49 cd	578.99 ab	512.33 ab	
Date* Marine – Fert	15-Sep	482.14 a	490.76 a	510.87 a	Effect of Hybrid	
	1-Oct	345.51 bc	321.84 c	381.64 b		
Marine Fert *Hybrid	Batavia	307.36 d	379.47 c	370.69 c	352.51 c	
	Covina	446.84 b	347.01 cd	386.80 c	393.55 b	
	lucky	487.28 b	492.42 b	581.28 a	520.33 a	
Effect of Marine Fert		413.83 b	406.30 b	446.26 a		

Values with the same letter in the column, row, or interactions are not significantly different according to Duncan's test at the 0.05 level.

Additionally, the highest value 581.28 g/plant of yield of side flower heads was recorded for plants that sprayed with Marine Fert at 2 mL L^{-1} and lucky type when compared with low value 307.36 g/plant for 0 mL L^{-1} Marine Fert interacted with Batavia type. The third interaction between date, and Marine Fert indicated that the yield of side flower heads was significantly increased which reached to 510.87 g/plant for the first date interacted with 2 mL L^{-1} Marine Fert respectively, compared with low yield of side flower heads to 321.84 g/plant for the plants first date and 1 mL L^{-1} with Marine Fert.

The triple interaction among the date of planting, hybrid type and Marine-Fert clarified that the plants which first date, lucky type and interacted with 2 mL L^{-1} 1 Marine-Fert gave the highest significant values 583.57 g/plant respectively, compared with the least value 183.34 g/plant for the plants second date, Batavia type and sprayed with 0 mL L^{-1} Marine-Fert.

1.3. Total Yield per Hectare for Main and Side Flower Heads (tons/ha).

The results in Table 3 demonstrated that the planting date did not have any significantly increased between them. Where as, the type of Lucky was significantly increased Total Yield of Side Flower Heads reached to 38.74 ton/ ha respectively, compared with another two types of Batavia type to 32.05 ton/ ha and Covina to 30.67 ton/ ha. However, foliar application of Marine-Fert had a significantly increased yield of side flower heads to 35.26 ton/ ha with the highest dose 2 mL L^{-1} which followed by least volue for the control 32.49 ton/ha.

Table (3) illustrates the effect of planting date, hybrids, and foliar application of Marine-Fert, and their interactions on Total yield per hectare for main and side flower heads(tons/ha)

Date Planting	Hybrid	Marine-Fert (mL L⁻¹) 0	1	2	Date *Hybrid	Effect of Date Planting
15-Sep	Batavia	33.01 c-e	35.28 bc	34.92 b-d	34.40 b	
	Covina	29.67 e	30.57 de	32.43 c-e	30.89 c	34.44 a
	lucky	36.26 bc	36.48 bc	41.33 a	38.02 a	
1-Oct	Batavia	28.67 e	29.88 e	30.57 de	29.70 c	
	Covina	30.70 de	30.56 de	30.09 e	30.45 c	33.20 a
	lucky	36.63 bc	39.52 ab	42.21 a	39.45 a	
Date* Marine – Fert	15-Sep	32.98 b	34.11 ab	36.23 a	Effect of Hybrid	
	1-Oct	32.00 b	33.32 b	34.29 ab		
Marine Fert *Hybrid	Batavia	30.84 c	32.58 c	32.75 c	32.05 b	
	Covina	30.19 c	30.57 c	31.26 c	30.67 b	
	lucky	36.45 b	38.00 b	41.77 a	38.74 a	
Effect of Marine Fert		32.49 b	33.72 ab	35.26 a		

Values with the same letter in the column, row, or interactions are not significantly different according to Duncan's test at the 0.05 level.

The interaction between date of planting and hybrid type of plant, the second date of planting intracted with Lucky type was significantly increased total yield of side flower heads reached to 39.45 ton/ha, respectivly, with the lowest was for second date of planting and Batavia type wich reached 29.70 ton/ha. Moreover , the highest value 41.77 ton/ ha of total yield of side flower heads was recorded for plants that sprayed with Marine Fert at 2 mL L^{-1} and lucky type respectivly, compared with low value 30.19 ton/ha for 0 ml.l-1 Marine Fert interacted with Covina type. The third interaction between date, and Marine Fert indicated that the total yield of side flower heads was significantly increased which reached to 36.23 ton/ha for the first date interacted with 2 mL L^{-1} Marine Fert respectively, compared with low total yield of side flower heads to 32.00 ton/ha for the second date of planting and plants trated with 0 mL L^{-1} Marine Fert.

The triple interaction among the three facotors clarified that the plants which second date, lucky type and interacted with 2 mL L^{-1} Marine-Fert gave the highest significant 42.21 ton/ha respectively, compared with the least value 28.67 ton/ha for the plants second date, Batavia type and sprayed with 0 mL L^{-1} Marine-Fert

2. Concentration of Minerals and Nutrients in the Curd
Nitrogen Percentage (%N) in the Head's Dry Matter.

Table (4) Effects of Planting Date, Hybrid Type, and Foliar Application of Marine-Fert on Nitrogen Percentage in the Head's Dry Matter

Date Planting	Hybrid	Marine-Fert (mL L⁻¹) 0	1	2	Date *Hybrid	Effect of Date Planting
15-Sep	Batavia	2.21 i	2.59 c	2.62 b	2.47 b	
	Covina	2.24 hi	2.09 j	2.54 d	2.29 c	2.28 a
	lucky	1.56 n	2.26 h	2.39 e	2.07 e	
1-Oct	Batavia	1.82 l	1.87 k	2.24 hi	1.97 f	
	Covina	1.75 m	2.36 f	2.32 g	2.14 d	2.20 b
	lucky	2.24 hi	2.66 a	2.57 c	2.49 a	

Date* Marine – Fert	15-Sep	2.00 e	2.31 c	2.52 a	Effect of Hybrid
	1-Oct	1.94 f	2.30 d	2.38 b	
Marine Fert *Hybrid	Batavia	2.01 e	2.23 d	2.43 c	2.22 b
	Covina	1.99 f	2.23 d	2.43 c	2.22 b
	lucky	1.90 g	2.46 b	2.48 a	2.28 a
Effect of Marine Fert		1.97 c	2.30 b	2.45 a	

Values with the same letter in the column, row, or interactions are not significantly different according to Duncan's test at the 0.05 level

The results in Table (4) exposed that the first planting date was significantly increased the Nitrogen percentage in the head dry matter to 2.28 % compared to the second date which reached to 2.20 %. However, the type of Lucky was significantly outperformed on Batavia type and Covina to 2.22 % with the highest average head weight reached to 22.28 %. However, foliar application of Marine-Fert had a significantly increased Nitrogen percentage to 446.26 g with the highest dose 2 ml. l^{-1} which followed by the 1 ml. l^{-1} treatment 2.30 %, respectivly compare with the control 1.97

The interaction between date of planting and hybrid type of plant, the second date of planting intracted with Lucky type was significantly increased Nitrogen Percentage reached to 2.44%, respectivly, with the lowest was for second date of planting and Bativa type wich reached 1.97. Additionally, the highest value 2.48% Nitrogen Percentage was recorded for plants that sprayed with Marine Fert at 2 ml. l-1 and lucky type when compared with least value 1.90 % for 0 mL L^{-1} Marine Fert interacted with Lucky type.The third interaction between date of planting and Marine Fert indicated that the nitrogen percentage was significantly increased which reached to 2.52 % for the first date interacted with 2 mL L^{-1} Marine Fert respectively, compared with low nitrogen percentage to 1.94 % for the second date of planting intracted with plants spryed 0 mL L^{-1} with Marine Fert.

The triple interaction among tree factors clarified that the plants which second date, lucky type and interacted with 1 mL L^{-1} Marine-Fert gave the highest significant values 2.66 % respectively, compared with the least value 1.56 % for the plants first date, lucky type and sprayed with 0 mL L^{-1} Marine-Fert.

Phosphorus Percentage (%P) in the Head's Dry Matter.

Table (5) Effects of Planting Date, Hybrid Type, and Foliar Application of Marine-Fert on Phosphorus Percentage in the Head's Dry Matter

Date Planting	Hybrid	Marine-Fert (mL L^{-1}) 0	1	2	Date *Hybrid	Effect of Date Planting
15-Sep	Batavia	0.398 n	0.393 o	0.426 l	0.405 f	0.418 b
	Covina	0.442 j	0.366 q	0.457 h	0.422 e	
	lucky	0.400 m	0.431 k	0.447 i	0.426 d	
1-Oct	Batavia	0.476 g	0.385 p	0.562 c	0.474 c	0.526 a
	Covina	0.582 a	0.543 d	0.564 b	0.563 a	
	lucky	0.562 c	0.536 e	0.528 f	0.542 b	
Date* Marine – Fert	15-Sep	0.413 e	0.397 f	0.443 d	Effect of Hybrid	
	1-Oct	0.540 b	0.488 c	0.551 a		
Marine Fert *Hybrid	Batavia	0.437 h	0.389 i	0.494 c	0.440 c	
	Covina	0.512 a	0.455 g	0.511 b	0.493 a	
	lucky	0.481 f	0.484 e	0.487 d	0.484 b	
Effect of Marine Fert		0.477 b	0.442 c	0.497 a		

Values with the same letter in the column, row, or interactions are not significantly different according to Duncan's test at the 0.05 level

According to Table 5 illisturated that the second planting date was significantly increased the Phosphorus percentage in the head dry matter to 0.526 % compared to the second date which reached to 0.418 %. As well as, the type of Covina was significantly superrire on Batavia and Lucky type to 0.440 %, 0.484 % with the highest average head weight reached to 0.493 %. However, foliar application of Marine-Fert had a significantly increased Phosphorus percentage to 0.497 % with the highest dose 2 mL L^{-1} which followed by the 1 mL L^{-1} reached 0.442 %.

The third interaction between date of planting and Marine Fert indicated that the Phosphorus percentage was significantly increased which reached to 0.551 % for the second date interacted with 2 mL L^{-1} Marine Fert respectively, compared with low Phosphorus percentage to 0.413 % for the first date of planting intracted with plants spryed 0 mL L^{-1} with Marine Fert.

The triple interaction among tree factors clarified that the plants which second date, Covina type and interacted with 0 mL L^{-1} Marine-Fert gave the highest significant values 0.582 % respectively, compared with the least value 0.393 % for the plants first date, Batavia type and sprayed with 1 mL L^{-1} Marine-Fert

Potassium Percentage (%K) in the Head's Dry Matter.

Table (6) Effects of Planting Date, Hybrid, and Marine-Fert on Potassium Percentage in Broccoli Head's Dry Matter

Date Planting	Hybrid	Marine-Fert (mL L^{-1}) 0	1	2	Date *Hybrid	Effect of Date Planting
15-Sep	Batavia	6.21 a-c	5.58 e	5.73 c-e	5.84 bc	5.94 b
	Covina	5.93 b-e	5.87 b-d	5.61 de	5.81 c	
	lucky	6.05 a-e	6.26 a-c	6.19 a-c	6.16 a	
1-Oct	Batavia	6.03 a-e	5.92 b-e	6.32 ab	6.09 a-c	6.10 a
	Covina	5.49 e	6.53 a	6.38 ab	6.13 ab	
	lucky	6.15 a-d	5.93 b-e	6.17 a-d	6.08 a-c	
Date* Marine – Fert	15-Sep	6.06 ab	5.90 b	5.84 b	Effect of Hybrid	
	1-Oct	5.89 b	6.13 ab	6.29 a		
Marine Fert *Hybrid	Batavia	6.12 ab	5.75 bc	6.02 a-c	5.96 a	
	Covina	5.71 c	6.20 a	6.00 a-c	5.97 a	
	lucky	6.10 ab	6.10 ab	6.18 a	6.12 a	
Effect of Marine Fert		5.98 a	6.02 a	6.07 a		

Values with the same letter in the column, row, or interactions are not significantly different according to Duncan's test at the 0.05 level.

According to Table 6 revealsed that the second planting date was significantly increased the Potassium Percentage in the head's dry matter to 6.10 % compared to the first date which reached to 5.94 %. Where as, the hybrid type of plant and any concentration of Marine-Fert was not have any significantly effected btween them.

The interaction between date of planting and hybrid type of plant, the first date of planting intracted with lucky type was significantly increased Potassium Percentage reached to 6.16 %, respectivly, compared with the lowest volue for first date of planting and Covina type wich reached 5.81 %. Moreover, the highest value of Potassium Percentage to 6.20 % was recorded for plants that sprayed with Marine Fert at 1 mL L^{-1} and Covina type when compared with least value 5.71 % for 0 mL L^{-1} Marine Fert interacted with Covina type. The third interaction between date of planting and Marine Fert indicated that the Potassium percentage was significantly increased which reached to 6.29 % for the second date interacted with 2 mL L^{-1} Marine Fert respectively, compared with low Potassium percentage to 5.84 % for the first date of planting intracted with plants spryed 2 mL L^{-1} with Marine Fert.

The triple interaction among tree factors clarified that the plants which second date, Covina type and interacted with 1 mL L^{-1} Marine-Fert gave the highest significant values 6.53 % respectively, compared with the least value 5.49 % for the plants second date, Covina type and sprayed with 0 mL L^{-1} Marine-Fert

Discussion

The results showed that the planting date had a significant effect on the main head weight, with the second planting date recording a higher flower head weight compared to the first date. This suggests that late planting provided favorable environmental conditions for head growth, consistent with [23], which indicated that moderate temperatures during the final growth stages enhance broccoli flower development. Regarding side shoot production, the first planting date had a higher yield than the second. This may be due to early planting allowing for better vegetative growth before head formation, leading to increased side shoot development, as confirmed by [24].

In terms of nutrient content, the nitrogen percentage was higher in the first planting date compared to the second, suggesting that early planting enhanced nitrogen uptake.During the growing season, average maximum temperatures were 42.5°C in August, 36.6°C in September, and 29.0°C in October (Directorate of Meteorology, Duhok, 2025). The gradual cooling toward October provided more moderate temperatures, which likely improved phosphorus and potassium uptake in broccoli, as supported by [25].

This result may also be due to the appropriate environmental conditions of maximum and minimum temperatures and photoperiod during the sowing date, which led to increased vegetative growth. This vegetative expansion enhances the efficiency of the photosynthesis process, contributing to the accumulation of carbohydrates in the leaves and their transfer to active growth regions. Additionally, the second planting date plants may have undergone vernalization more than others, which is essential for curd initiation in broccoli. The increase in all vegetative traits led to more nutrient synthesis, their transfer and accumulation in active plant parts, thus enhancing yield. This aligns with [26] and [27], who stated that broccoli requires a moderate climate leaning toward warmth during its early vegetative stage.

The superiority of the second planting date in yield and its components, including total productivity, may be attributed to favorable climatic conditions that supported vegetative growth and promoted nutrient accumulation in the plant, which led to increased total yield. This is consistent with the findings of [28], who reported that broccoli (*Brassica oleracea* var. *italica* cv. Green Magic) sown at later dates (e.g., November 1) exhibited significantly greater vegetative growth (plant height, number and length of leaves) and higher total yield compared to earlier planting dates. They concluded that moderate temperature conditions in the later planting period improved physiological performance and nutrient uptake, leading to better crop productivity

The results revealed that the Lucky hybrid outperformed the other hybrids in all yield traits, recording the highest main head weight and the highest side shoot yield compared to Batavia and Covina. These results confirm that genetic differences among hybrids play a crucial role in productivity, as highlighted in [29], who found that hybrids exhibit different responses to environmental and nutritional conditions. Regarding nutrient content, Lucky recorded the highest nitrogen and potassium percentages, indicating superior nutrient uptake efficiency, while Covina recorded the highest phosphorus percentage, reflecting differences in nutrient absorption efficiency among hybrids, as supported by [30].

As for the foliar application of Marine-Fert, it had a significant positive effect on all yield traits. The 2 mL L^{-1} concentration increased flower head weight, head yield, total yield, and nutrient content (nitrogen and phosphorus percentages). The positive impact of the seaweed extract on foliage and harvest components of broccoli may be attributed to its content of plant hormones like cytokinin and auxin, as well as vitamins, polysaccharides, fatty acids, betaine-like compounds, amino acids, and macro- and micronutrients, which stimulate plant growth and yield, as reported in [31] and [32]. Similar results were reported in [14] and [16], who demonstrated significant improvements in growth and yield due to foliar application of seaweed extract.

Conclusion

Based on the findings, it can be concluded that the optimal cultivation of broccoli in the conditions studied is achieved by planting in October, using the Lucky hybrid, and applying Marine-Fert at a concentration of 2 mL L^{-1}. These conditions significantly improve growth parameters, yield, and nutrient content, indicating their effectiveness in enhancing broccoli production in the region.

References:

[1]. Hassan, A. (2003). Production of cabbage and sage greens. The Arab House for Publishing and Distribution, Cairo.

[2]. Dev, D. (2012). Standardization of planting time and spacing in broccoli cv. Green Head for lower hills of Northern India. *International Journal of Farm Sciences*, 2(1), 36–42.

[3]. Francisco, M., Tortosa, M., Martínez-Ballesta, M. C., Velasco, P., García-Viguera, C., & Moreno, D. A. (2017). Nutritional and phytochemical value of Brassica crops from the agrifood perspective. *Annals of Applied Biology*, 170, 273–285.
[4]. Thapa, U., & Rair, R. (2012). Evaluation of sprouting broccoli (Brassica oleracea var. italica) genotypes for growth, yield and quality. *International Journal of Agriculture Sciences*, 4(7), 284–286.
[5]. Rahman, M., Rashid, M. H., Shahadat, M. K., Chowdhury, A. K., & Ali, M. A. (2020). Effect of planting dates on performance of broccoli in coastal area of Bangladesh. *Bangladesh Journal of Agricultural Research*, 45(4), 419–429.
[6]. Al-Habar, M. T., & Al-Rashedy, A. M. (2014). Effect of planting dates, varieties and foliar application of boron on quality and quantity of yield of cauliflower (*Brassica oleracea var. botrytis*). *Mesopotamia Journal of Agriculture*, 22(1), 63–79.
[7]. Shehata, S. A., Ahmed, O. K., Abd El-All, H. M., Mahmed, M. A., & Abd El Gawad, K. F. (2017). Effect of transplanting date and cultivar on growth, yield and quality of broccoli. *Fayoum Journal of Agricultural Research and Development*, 31(1), 58–71. https://doi.org/10.21608/fjard.2017.191230
[8]. Al-Sudani, Z. A. J., & Al-Bayaty, N. M. H. (2020). Effect of planting date and phosphate fertilization on growth and yield of broccoli plant in southern Iraq. *Diyala Agricultural Sciences Journal (DASJ)*, 12(1), 66–78.
[9]. Khan, W., Rayirath, U. P., Subramanian, S., Jithesh, M. N., Rayorath, P., Hodges, D. M., Critchley, A. T., Craigie, J. S., Norrie, J., & Prithiviraj, B. (2009). Seaweed extracts as biostimulants of plant growth and development. *Journal of Plant Growth Regulation*, 28, 386–399.
[10]. Craigie, J. S. (2011). Seaweed extract stimuli in plant science and agriculture. *Journal of Applied Phycology*, 23, 371–393.
[11]. Hamed, S. M., El-Rhman, A. A. A., Abdel-Raouf, N., & Ibraheem, I. B. M. (2018). Role of marine macroalgae in plant protection & improvement for sustainable agriculture technology. *Beni-Suef University Journal of Basic and Applied Sciences*, 7(1), 104–110.
[12]. Rasheed, S. M., & Shareef, R. S. (2020). Effect of seaweed extract and plant spacing on growth and yield of two eggplant hybrids (*Solanum melongena L*.). *Journal of Duhok University*, 22(2), 101–112.
[13]. Pandey, G. P. (2024). Exploiting hybrid vigor for agricultural efficiency. In *Science of Plant Genetics* (pp. 93–109).
[14]. Al-Eezzi, Y. H., & Al-Alawy, H. H. (2022). Effect of fulvic acid and seaweed on the growth and yield of broccoli. *Journal of Pharmaceutical Negative Results*, 13(1), 583–587.
[15]. Baldaniya, J. K., Panchal, B. H., Rathod, M. B., & Macwan, S. J. (2023). Effect of biostimulants on growth and quality of broccoli (*Brassica oleracea var. italica)* cv. Pusa KTS-1. *The Pharma Innovation Journal*, 12(5), 667–670.
[16]. Halshory, H., Mahmood, A., & Tofiq, G. (2023). Effect of plant biostimulants on growth, yield and some mineral composition of broccoli plants (Brassica oleracea var. italica). *Tikrit Journal for Agricultural Sciences*, 23(1), 130–140.
[17]. Hartley, T. N., Maathuis, F. J., & Williams, P. N. (2023). Potassium nutrition enhances broccoli yield and quality: A field study. *Frontiers in Plant Science*, 14, 1123.
[18]. Kumar, R., & Singh, M. (2022). Impact of foliar application of micronutrients on the yield and quality of broccoli *(Brassica oleracea L. var. italica*). *Vegetable Science*, 49(1), 12–18.
[19]. Scuderi, D., Giuffrida, F., & Leonardi, C. (2023). Combined effect of planting density and nitrogen fertilization on yield and quality of broccoli. *Agronomy*, 13(2), 345.
[20]. Horneck, D. A. & Miller, R. O. (1998). Determination of total nitrogen in plant tissue. In Handbook of Reference Methods for Plant Analysis, Kalra, Y. P. (ed), Taylor & Francis Group, LLC, pp: 73
[21]. Kulhánek, M., Balík, J., & Černý, J. (2023). Colorimetric determination of phosphorus in plant material: A review. *Communications in Soil Science and Plant Analysis*, 54(5), 567–580.
[22]. Latimer, G. W., Jr. (Ed.). (2023). *Official Methods of Analysis of AOAC INTERNATIONAL* (22nd ed.). AOAC INTERNATIONAL. https://doi.org/10.1093/9780197610145.001.0001
[23]. Nooprom, J., & Santipracha, P. (2013). Effects of planting date on growth and yield of broccoli in tropical conditions. *Asian Journal of Horticultural Science*, 7(2), 89–96.
[24]. Abed, S. M., Al-Dulaimi, S. H., & Jasim, A. M. (2015). Influence of planting date on side branching and yield of cruciferous vegetables. *Journal of Agricultural Sciences*, 10(3), 112–120.
[25]. González, L. A., & Martínez, R. P. (2020). Temperature effects on phosphorus and potassium uptake in broccoli. *Plant Physiology Reports*, 25(4), 309–315.

[26]. Abdl-Rahman, H. B., & Mohammed, I. A. W. (2017). The effect of soil mulching and transplanting date on the growth and yield of two hybrids of cauliflower *Brassica oleracea var. botrytis. Tikrit Journal for Agricultural Sciences*, 17(4), 57–68.
[27]. Hassan, A. A. M. (2003). Production of cabbage and sage greens. The Arab House for Publishing and Distribution, Cairo.
[28]. Kanase, V. J., Bhosale, A. M., & Shinde, V. N. (2018). Studies on effect of planting dates on growth, yield and quality of broccoli (Brassica oleracea *L. var. italica*) cv. Green Magic. *International Journal of Current Microbiology and Applied Sciences*, *Special Issue-6*, 78–86
[29]. Huang, X., Chen, Y., & Lin, Z. (2016). Genetic variation among broccoli hybrids and its effect on yield and quality. *Journal of Horticultural Research*, 24(1), 23–35.
[30]. Poblaciones, M. J., García-Latorre, C., Velazquez, R., & Broadley, M. R. (2024). Effects of selenate application on growth, nutrient bioaccumulation, and bioactive compounds in broccoli (Brassica oleracea *var.* italica *L.*). *Horticulturae*, *10*(8), 808.
[31]. Baldaniya JK, Panchal BH, Rathod MB and Macwan SJ (2023). Effect of biostimulants on growth and quality of broccoli (*Brassica oleracea var. italica*) cv. Pusa KTS-1. *The Pharma Innovation Journal*; 12(5): 667-670.
[32]. Yasir, N. F., Seheib, M. W., & Hasan, O. A. (2016). Effect of adding different organic fertilizers in the absorption of some nutrient elements from soil in properties of plant growth and yield of cucumber plant. *Journal of Agriculture and Veterinary Science*, Volume 9, Issue 5 Ver. I, PP 13-17

"تأثير موعد الزراعة والرش الورقي بالسماد البحري (Marine-Fert) في النمو والإنتاجية ومحتوى الغذائي لثلاثة هجن من البروكلي (Brassica oleracea L. var. italica) تحت ظروف البيت البلاستيك

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الخلاصة

تم تنفيذ هذه التجربة خلال موسم الخريف لعام 2024 واستمرت حتى شهر آذار 2025 داخل بيت بلاستيكي بمساحة 500 م^2 في مشتل مالطا، التابع لمديرية البستنة في مدينة دهوك، إقليم كردستان، العراق.

كان الهدف الرئيسي من هذه الدراسة هو تقييم تأثير عاملين رئيسيين هما: موعد الزراعة (15 سبتمبر و1 أكتوبر)، وثلاثة هجن من البروكلي***Batavia*** ، ***Covina***، ***Lucky***، بالإضافة إلى ثلاث تراكيز من مستخلص الطحالب البحرية***0 (Marine-Fert)*** ، 1، و2 مل/لتر)، على مجموعة من النمو والإنتاجية لنبات البروكلي تحت ظروف الزراعة المحمية.

تمت الرشات الورقية بمستخلص ***Marine-Fert*** ثلاث مرات خلال موسم النمو؛ حيث أُجري أول رش بعد 15 يومًا من التشتيل، وتكررت الرشات بفاصل 15 يومًا بين كل واحدة. وقد صُممت التجربة لقياس تأثير هذه العوامل على النمو الخضري و الانتاجية والمحتوى الغذائي للنبات.

أظهرت النتائج أن موعد الزراعة الثاني (1 أكتوبر) أدى إلى تحسين معنوي في بعض الصفات، مثل وزن الرأس الرئيسي للنبات (978.44)غرام، ومحتوى الفوسفور (0.526%)، والبوتاسيوم (6.10%). في المقابل، ساهم موعد الزراعة الأول (15 سبتمبر) في زيادة محصول الأقراص الجانبية للنبات(494.59) غرام ومحتوى النيتروجين.***(2.28%)***

أما بالنسبة للهجن، فقد أظهر الهجين ***Lucky*** تفوقًا واضحًا من خلال تحقيق أعلى القيم في وزن الرأس الرئيسي للنبات (1029.17)غرام و محصول الأقراص الجانبية للنبات(520.33)غرام، المحصول الكلي (38.74 طن/هكتار)، ومحتوى النيتروجين.***(2.28%)***

وأظهرت النتائج أيضًا أن الرش الورقي بمستخلص ***(Marine-Fert)*** بتركيز 2 مل/لتر أعطى أفضل النتائج من حيث النمو والإنتاجية، مما يؤكد الدور الفعّال لاستخدام مستخلص الطحالب البحرية في تحسين النمو والمحصول.

تؤكد هذه الدراسة على أهمية اختيار موعد الزراعة المناسب، والهجين الملائم، والتركيز الفعّال من السماد الورقي (***Marine-Fert***) لتحقيق أعلى إنتاجية لنبات البروكلي في الزراعة المحمية.

الكلمات المفتاحية: موعد الزراعة، البروكلي، الهجن، مستخلص الطحالب البحرية، النمو، الحاصل.