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Effect of different planting dates on growth and yield of three broccoli hybrids. (Brassica oleracea var.italica).

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Abstract: The present study was conducted during the 2024/2025 growing season in the agricultural fields of Kalar Horticultural Station in Sulaymaniyah province to evaluate three hybrids grown at *Brassica oleracea* var. *(*different planting dates and their effects on some growth and yield of broccoli on some growth and yield of broccoli plant. This study identifies optimal planting dates and) Italica hybrids to boost broccoli yield and quality. It promotes sustainable practices, supports food security, and enhances farmer incomes. Despite challenges in broccoli cultivation due to suboptimal planting practices and limited research, farmers lack guidance on optimal planting times and hybrids. This study examines planting dates and hybrid effects to offer practical solutions for improved yield and quality in Sulaymaniyah Governorate/Iraq. Thereby, this research seeks to establish the ideal planting period and select the most appropriate broccoli hybrid for effective cultivation under the agroclimatic conditions. In this experiment, a complete randomized design (CRD) with three replicates was used. Three broccoli hybrids, V_1: Wisdom, V_2: Hana, V_3: Hapa were grown at The first factor included three planting dates, D_1: 1_{st} September, D_2: 15_{th} September and D_3: 30_{th} September, The findings notable disparities, with first date (1_{st} September) exhibiting superior performance, demonstrated giving a plant height of (40.48 cm), leaves per plant (17.06 leaves plant^{-1}), Leaf area (409.71 cm^2), Chlorophyll content in leaves (72.26 SPAD), Flower disc diameter (17.22 mm), flower disc weight per plant (512.93 g plant^{-1}), and the total yield of tubers (61.46 tons. ha^{-1}). The combined effect of two factors, namely planting dates and hybrids, and it is worth noting that the interaction between the first date and hybrid wisdom, had a significant effect on all vegetative growth and yield parameters, resulting in the highest plant height (cm), number of leaves (leaves per plant^{-1}), leaf area, chlorophyll Interaction. Based on these results, it can be .percentage, flower disc weight and total yield (t ha^{-1}) concluded that the planting date (1_{st} September) and broccoli hybrid Wisdom (V_1) can be successfully grown in the agro-climatic conditions of Iraq. The results show that planting date significantly impacts broccoli yield, while hybrid choice does not. The interaction between hybrids and planting dates is also insignificant. Thus, selecting the optimal planting date is more crucial for maximizing yield than choosing a specific hybrid variety. Future research may investigate additional hybrids, environmental factors, and multi-season data to optimize planting schedules and broccoli yield, with climate modeling enhancing strategies.

Keywords: planting date, Broccoli hybrids, Growth Parameters, Agricultural fields.

** Part of the doctoral thesis of the first author.*

1. INTRODUCTION

Broccoli is a winter vegetable (*Brassica oleracea* var. italica), which belongs to the cruciferous family (Brassicaceae), which also includes cabbage, cauliflower, kale, and Brussels sprouts. It is widely recognized for its nutritional value and health benefits, making it a staple in healthy diets around the world. (Nagraj, et al 2020). The demand for the crop by consumers has increased recently, as the demand for it in the global markets because of its high nutritional value and distinctive taste, which was proven by the increase in the cultivated area of the crop and the increase in production significantly in all global markets (Jing et al., 2011). Nutritionally, it is rich in vitamin-A (2500 IU),

vitamin- C (113 mg), protein (3.6 g), carbohydrates (5.9 g) and minerals like calcium (103 mg), iron (1.1 mg), phosphorus (78 mg), potassium (382 mg) and sodium (15 mg) per 100g of edible portion(Nagraj et al.,2020), In addition, broccoli is a rich source with sulforaphane, which has been demonstrated to bring down cancer and reduce the body process of cancer cells because they carry high levels of glucosinolates (Nandini et al, 2020). As for its medical benefits, various researchers have confirmed that broccoli is beneficial to health as helps in the treatment of many common diseases. It serves to bring down the level of cholesterol in the blood and lowers high blood pressure, it also helps to protect against heart disease, particularly in the treatment and prevention of coronary artery disease. It also helps to regulate blood sugar levels. (Baladia, C.J., et al. 2024).
One of the most important agricultural operations which increase the productivity of Broccoli is the cultivation of this crop at different dates during the same season in order to prolong the presence of this crop in the market and for the longest possible period of time that can be achieved through successive planting, i.e. cultivation of the same variety. So that, this study is significant for improving broccoli production in the region. By identifying optimal planting dates and high-performing hybrids, it offers farmers evidence-based strategies to enhance yield and quality. The research promotes sustainable practices, such as organic fertilization and efficient irrigation, contributing to environmental conservation and soil health. The findings can guide agricultural programs, ultimately supporting food security, farmer incomes, and sustainable agricultural development. Meanwhile, this study provides actionable insights for optimizing broccoli cultivation in the South of Sulaymaniyah Governorate. It identifies the best planting date (September 1st) and hybrid (Wisdom) for maximizing growth, yield, and quality. The study emphasizes the role of organic fertilization, soil preparation, and drip irrigation, offering a sustainable framework for improving broccoli production in similar agroclimatic regions. Although, broccoli cultivation in the South of Sulaymaniyah Governorate faces challenges due to suboptimal planting practices and a lack of region-specific research. Farmers struggle to determine the best planting times and hybrid varieties for maximum yield and quality. This study investigates the effects of planting dates and hybrid varieties on broccoli growth and productivity, aiming to provide practical solutions for local farmers. To the end that, this study was conducted with an objective to finding out optimum planting time and to select suitable hybrid of broccoli for successful cultivation under agro climatic conditions of Sulaymaniyah Governorate/Iraq.

2. MATERIAL AND METHODS

The present study was carried out at the experimental farm of Kalar Horticultural Station in Sulaymaniyah Governorate, Iraq. During the growing season of 2024/2025 to evaluate three hybrids grown at different planting dates and their effects on some growth traits of broccoli plant. In this experiment, a complete randomized design (CRD). The design was a split plot with complete randomized design with three replicates was used. Each replicate consisted of 9 experimental units. The main plots were planting dates, D_1: 1_{st} September, D_2: 15th September and D_3: 30_{th} September, respectively. With subplots of early broccoli varieties: V_1: Wisdom, V_2: Hana, V_3: Hapa. Seeds of three broccoli hybrids were planted in seed trays with appropriate care. After that, the seedlings at the four-leaf stage were transferred to experimental units on three planting dates, the field was prepared for cultivation by removing the weeds, then plowing with a rotary plough. Plowing was done perpendicularly twice and to a depth of about 0.40 m, then the soil was smoothed and leveled using a rotary plough. Then, the field was fertilized by adding decomposed organic poultry manure (to the soil before cultivation at a rate of 6 kg/m2), (Jithender et al., and 2017). Well adjusted. Then the field land was divided into three replicates, and each replicate contained the three hybrids randomly so that every 9 meters includes one hybrid, And another 45 cm, leaving a distance of 1 m between each repeater, and then animal manure was added to all experimental units. The drip irrigation system was used to irrigate the plants in the field. Random

samples were taken from different places of the field soil before planting and fertilization, at depths of (30-0 cm in the shape of the letter X, then the samples were mixed together homogeneously and a sample was taken and then ground and passed through a sieve with a diameter of 2 mm holes to know the characteristics of representative soil of the field. The chemical and physical characteristics of the field soil were air dried in the soil laboratory - General Directorate of Agriculture of Garmian - Kalar Research Station, and Table (1) shows the chemical and physical characteristics of the soil of the field under study according to the method mentioned in (Black, 1965). Table (1) some chemical and physical characteristics of the soil of the field in which the experiment was carried out. The average maximum and minimum temperatures were recorded during the study period Table 2.

Table1. Some chemical and physical characteristics of the soil of the field

properties		value		
pH		7.6		
EC ds m^{-1})at 25co		1.4		
(g kg^{-1}) CaCO3		315		
(g kg^{-1}) O.M		4.2		
Zn total (mg kg^{-1})		55.23		
% Field capacity		25.05%		
% wilting point		16.80%		
Soil Texture (g kg^{-1})		Sandy Clay Loam	Sand	456.5
			Silt	198.0
			Clay	345.5
CEC	Cmolckg^{-1}	25.50		
Soluble Ions MmolcL^{-1}	se	0.30		
	Ca^{+2}	17.3		
	Mg^{+2}	2.5		
	K^{+}	0.25		
	Na^{+}	1.60		
	Cl	0.65		
	HCO3	2.8		
	$SO4^{-2}$	2.58		

Table 2. Some of agro-climatological data for the experiment locations during the 2024/2025 growing season.

Month	HC Air temperature [°C]			Relative humidity [%]
	Min	Max	Avg.	
Sep.	17.39	38.46	27.925	65.78
Oct.	15.16	33.72	24.44	64.53
Nov.	13.73	28.45	21.09	79.48
Dec	11.35	25.71	18.53	80.37
Jan	8.77	19.35	14.06	81.72
Feb	6.61	13.57	10.09	83.82

Experiment measurements

2.1. Vegetative traits

Six plants were randomly selected from each experimental unit to measure the following vegetative growth-related traits:

2.1.2. Plant height (cm)

The average height of six plants was calculated by measuring their heights using matric tape from the point where the stem and soil surface met to the end of the stem height. (Ajil and Al Kareem, 2012).

2.1.3. Leaves number (Number plant^{-1})

To calculate the number of leaves per plant, six plants were counted from each experimental unit, and an average was calculated. . (Al Kareem and Al Ajil, 2012).

2.1.4. Leaf area (cm^2)

The leaf area was calculated according to the following equation of Watson and Watson (1953):

$$\text{Leaf area} = \frac{\text{Area of one leaf (cm}^2\text{)}}{\text{Number of leaves from one plant}} \times 100$$

2.1.5. Chlorophyll% (SPAD)

The chlorophyll content of leaves was measured using the Konica Minolta, INC. Chlorophyll Meter, SPAD-502. As mentioned by Biscontin, and Pestana (2001).

2.2. Yield traits

2.2.1. Flower disc diameter (cm):

2.2.1. Flower disc weight (g.plant^{-1}).

2.2.4. The total yield (ton.ha^{-1})

By calculating the plant yield for each experimental unit and converting it to yield per hectare, the experimental unit yield = the average yield of one plant x the number of plants in the experimental unit. (Ibrahim, 2007).

2.3. Statistical Analysis

All analyses of the recorded data were performed using analysis of variance (ANOVA) according to the complete randomized design (CRD) model, according to the factorial order of experiments as stated in (Steel and Terrie, 1980). The least significant difference (LSD0.05) test helped to compare and separate the means of differences for all parameters, using the GenStat12 statistical program dedicated to this analysis.

3. Results and Discussions

3.1. Effect of planting dates on the growth characteristics of broccoli hybrids during the 2024/2025 season.

3.1.1. Plant height (cm)

The results showed a significant variation in broccoli planting dates (Table 3). In particular, the first date at the beginning of September (1/9) was the most successful, recording the tallest plant height of 40.48 cm. In contrast, the third date at the end of September (30/9) had the lowest height, reaching 31.80 cm. The significant plant height may be attributed to the favorable environmental conditions that facilitated vegetative growth at the beginning of the growing season, as temperatures play a vital role in facilitating cell division and elongation processes. (Duarte, 2015; Chen et al., 2022; Albaladejo et al., 2024). In the effect of hybrids, it is noted that the highest plant height reached 41.60 cm in the Wisdom hybrid, and it is noted that there is no significant difference

between the hybrids Hana and Hapa in plant height. Regarding the interaction between planting dates and hybrids, the treatments of planting date 1/9 for the hybrids Wisdom showed the highest plant height, which reached 45.64 cm, and these values were significantly different from all other treatments. In contrast, the lowest plant height, which reached 29.57 cm, was observed at planting date 30/9 for the hybrid Hapa. (Mohammed, and Saeid, 2024).

Table 3. Effect of Date of planting, Hybrid, and their interaction on plant height (cm) of three broccoli hybrids.

Date of planting × Hybrid	Hybrid			
	Wisdom Hybrid (V_1)	Hana Hybrid (V_2)	Hapa Hybrid (V_3)	Mean (cm)
1st September (D_1)	62.48	50.34	57.39	56.74
15th September (D_2)	56.47	52.72	52.37	53.85
30th September (D_3)	50.95	34.76	41.46	42.39
Means (cm)	56.63	45.94	50.41	
	Date of transplanting	Hybrid	Date of transplanting × Hybrid	
$LSD_{0.05}$	0.643	0.796	1.405	

3.1.2. Number of leaves (leaf. plant^{-1})

We note from the results in Table (2) indicate that the number of broccoli leaves increases at the early planting date in early September, the significantly excelled of the planting date 1/9 over the two planting dates 15/9 and 30/9, and it gave the most number of leaves 17.06 leaves. Plant-1, and the planting date 15/9 was excelled on the date 30/9 in this trait, and the lowest number of leaves found at planting dates 30/9 was 13.40 leaves. Plant-1. This result correlated with the study of El-Magd (2013), Shaplaet al (2014), Hafiz et al (2015) and Islam et al (2015).As for the effect of the hybrid, the hybrid plants "Wisdom" outperformed in this trait, followed by the hybrid plants "Hanah and Hapa", with a significant difference, respectively In the interactions, it is noted from the same table regarding the interaction between the planting date and the hybrids that the treatments of the planting date 1/9 in the hybrid wisdom gave the highest plant heights, which were 20.23 leaves. Plant-1, and they differed significantly with all other treatments, and the lowest plant height was 11.23 leaves. Plant-1 observed at the planting date. 30/9 for the hana hybrid. In this study, the variation in the number of leaves per plant can be attributed to the genetic makeup of the genotype and its ability to adapt to the prevailing environmental conditions. These results are in line with the findings of Ahmed and Siddiq (2004), Kumar et al., Thapa and Rai (2012), Njoli and Biswas (2014), Abul-Majd et al. in broccoli, as well as Kortar (2006) in Brussels sprouts, and Moniruzzaman (2011) in cabbage.

Table 4. Effect of Date of planting, Hybrid, and their interaction on the leaves per plant of three broccoli hybrids.

Date of planting × Hybrid	Hybrid			
	Wisdom Hybrid (V_1)	Hana Hybrid (V_2)	Hapa Hybrid (V_3)	Mean
1st September (D_1)	20.23	16.54	14.42	17.06
15th September (D_2)	17.66	20.15	12.75	16.85
30th September (D_3)	15.86	13.12	11.23	13.40
Mean	17.92	16.60	12.80	
	Date of transplanting	Hybrid	Date of transplanting × Hybrid	
$LSD_{0.05}$	0.197	0.148	0.312	

3.1.3. Leaf area (cm^2 $plant^{-1}$)

According to Table (5), the maximum leaf area (409.71 cm^2) was obtained on the 1/9 planting date. $Plant^{-1}$, and the planting dates 15/9 and 30/9, which varied significantly, produced the lowest leaf area (390.67 and 368.18 cm^2). $Plant^{-1}$'s leaf area, clearly shows that the hybrid Hana performs better than the hybrid Wisdom and Hapa. In the bi-interaction between the dates of planting and hybrids, we note that the treatments of the date 9/1 for planting with hybrid Hana and gave the most leaf area 501.23 cm2. Plant-1, and it differed significantly with all treatments, and the least leaf area was for the planting date 30/9 when hybrid Hapa283.62cm^2. Plant-1.The increase in leaf area of broccoli after early planting can be attributed to several interrelated physiological and environmental factor. These factors interact with the plant's growth cycles, soil conditions, and climatic influences, which are particularly relevant for a cool-season crop like broccoli (*Brassica oleracea* var. italica). Broccoli thrives in cooler temperatures (around 60–70°F or 15–21°C), which typically occur in early spring. Planting early allows broccoli to take advantage of these optimal growth temperatures, leading to quicker and more robust leaf development (Ilahy, et al. 2020).

Table 5. Effect of planting dates, hybrids and the interaction between them on the leaf area (cm2. $Plant^{-1}$) of three broccoli hybrids.

Date of planting × Hybrid	Hybrid			
	Wisdom Hybrid (V_1)	Hana Hybrid (V_2)	Hapa Hybrid (V_3)	Mean
1st September (D_1)	405.78	501.23	322.12	**409.71**
15th September (D_2)	381.11	471.43	319.47	**390.67**
30th September (D_3)	370.19	450.72	283.62	**368.18**
Mean	385.69	474.46	308.40	

	Date of transplanting	Hybrid	Date of transplanting × Hybrid
$LSD_{0.05}$	1.689	0.989	2.196

3.1.3. Chlorophyll content in leaves % (SPAD)

Table 6 indicates that the chlorophyll content in leaves of broccoli hybrids influenced by different planting dates but differences could not reach to the level of significance. The chlorophyll content produced under D_1, D_2 and D_3 planting dates was 75.26, .6811 and .7437 SPAD units, respectively. The timing of planting (e.g., early vs. late) can also affect chlorophyll levels, as early-planted hybrids typically have the advantage of cooler temperatures and increased sunlight, leading to enhanced chlorophyll activity (Obaid, et al. 2019). However, total chlorophyll was not significantly affected by cultivars. were also presented by Kopsell et al. (2004).The chlorophyll content in the leaves of broccoli hybrids V_1, V_2 and V_3 recorded 76.65,70.11 and 70.98 SPAD units, respectively. The interaction between broccoli hybrids and planting dates significantly affected the chlorophyll content of leaves. The interaction between D_1 x V_1 treatments produced the highest chlorophyll content (81.12 SPAD units), whereas the lowest chlorophyll content was recorded under interaction between D_3 x V_2 (62.32 SPAD units) treatments. It was observed from the results presented in Table 6 that the relative content of chlorophyll in the leaves was higher in hybrid Wisdom (V_1) might be due to higher number of leaves and leaf area in this hybrid V_1, which positively affected content of chlorophyll in leaves. The increase in the percentage of chlorophyll in certain broccoli hybrids is influenced by a combination of genetic traits, environmental factors, nutrient management, and physiological adaptations. (Kim, et al. 2021; Al-Hussainy, et al., 2019).

Table 6. Effect of planting dates, hybrids and the interaction between them Chlorophyll% (SPAD) of three broccoli hybrids.

Date of planting × Hybrid	**Hybrid**			
	Wisdom Hybrid (V_1)	**Hana Hybrid (V_2)**	**Hapa Hybrid (V_3)**	**Mean**
1st September (D_1)	81.12	74.5	70.16	75.26
15th September (D_2)	72.46	73.52	69.56	71.85
30th September (D_3)	76.36	62.32	73.22	70.63
Mean	76.65	70.11	70.98	
	Date of transplanting	Hybrid	Date of transplanting × Hybrid	
$LSD_{0.05}$	N/A	N/A	1.621	

3.1.5. Flower disc diameter (cm)

The outcomes shown in Table 6 provide a significant effect between the the planting date, as the early planting date of (september1) gave the maximum average of 17.62 mm, compared with the ate

planting date of (September 30), which exhibited the minimum average 13.62 mm. Planting date combinations are crucial in improving and increasing plant growth, as early planting date enhances the growth of leaves and stems, contributes to the formation of proteins, and enhances vegetative growth. Phosphorus also contributes to developing roots and flowers while helping tolerate different environmental conditions, contributing to plant strength. These positive effects manifested in increasing the disc diameter of the broccoli plant. Therefore, improving the balance between these three dates supports ideal growth, as reflected in raising the diameter of the disc (Al-Jubouri and Al-Hamdany, 2021). The results from Table 6 detailed a remarkable effect between hybrids, as the concentration of Wisdom hybrid provided the highest average of 17.25 mm. However, it did not differ significantly from the Hapa hybrid, which gave an average of 14.22 mm, compared with the Hapa hybrid, reaching an average of 15.58 mm. The interaction between broccoli hybrids and planting dates was significant with regard to Flower disc diameter, the interaction between treatments D_1 x V_1 the diameter of the flower disc is much larger. 19.87 mm.compared to treatment V_3 x D_2 which produced the lowest the diameter of the flower disc. 12.49 mm. These results are in line with the findings of (Hafiz et al., 2015).

Table 7. Effect of planting dates, hybrids and the interaction between on the flower disc diameter of three broccoli hybrids.

Date of planting × Hybrid	Hybrid			
	Wisdom Hybrid (V_1)	Hana Hybrid (V_2)	Hapa Hybrid (V_3)	Mean
1st September (D_1)	19.87	15.35	17.64	17.62
15th September (D_2)	16.78	14.81	15.82	15.80
30th September (D_3)	15.11	12.49	13.27	13.62
Mean	17.25	14.22	15.58	
	Date of transplanting	Hybrid	Date of transplanting × Hybrid	
$LSD_{0.05}$	0.513	0.321	1.497	

3.1.6. Flower disc weight (g.plant^{-1})

The results in Table 5 showed a significant effect between planting dates , where the first date (September 1) had the highest mean (512.93 g plant^{-1}) compared to the third date (September 30) with the lowest mean weight for the mentioned trait (413.85 g plant^{-1}). The noticeable increase in the mentioned trait may be due to the significant contribution of (Salman and Razzaq, 2022). Planting dates also affected the hybrid flower disc weight, as hybrid V_3 gave a significantly higher flower disc weight (487.48 g plant^{-1}), followed by hybrid V_2 (480.41g plant^{-1}),The lowest flower disc weight (34.66 g plant^{-1}) was recorded in hybrid V_1 of broccoli. The results from the same table also indicated a significant interaction between the factors, as the highest interaction appeared between the planting dates (September 1) and the hybrid Hapa V_3 with an average of 525.25 g plant^{-1}. While there was less interference in thethird date for both hybrids wisdom, Hana, which gave an average of 406.93, 415.04 g plant^{-1}. These results are in line with the findings of (Yaseen, & Ahmed. 2017; Zubaidi, et al., 2022).

Table 8. Effect of planting dates, hybrids and the interaction between them on flower disc weight of three broccoli hybrids.

Date of planting × Hybrid	Hybrid			
	Wisdom Hybrid (V_1)	Hana Hybrid (V_2)	Hapa Hybrid (V_3)	Mean
1st September (D_1)	496.66	516.88	525.25	512.93
15th September (D_2)	496.60	509.31	517.59	507.83
30th September (D_3)	406.93	415.04	419.59	413.85
Mean	466.73	480.41	487.48	
	Date of transplanting	Hybrid	Date of transplanting × Hybrid	
$LSD_{0.05}$	0.772	0.392	1.632	

3.1.7. The total yield of tubers (ton.ha^{-1})

From the data in Table (7), it is clear that the planting date on September 1 achieved the highest total productivity of main discs, reaching 61.32 tons. ha^{-1}, and there was a significant difference compared to the planting dates on September 15 and September 30. On the other hand, the lowest productivity of main flowering discs was recorded at the planting date on September 30, reaching 59.88 tons. ha^{-1}, The same table also shows that the Wisdom hybrid V_1 produced the highest total yield 55.15 tons. ha^{-1} compared to the Hapa hybrid V_3 which gave 48.49 tons. ha^{-1}. While the Hana hybrid V_2 of broccoli recorded the lowest productivity of flowering discs, reaching, 39.72 tons. ha^{-1}. The difference between hybrids could be the reason for achieving the highest total yield of broccoli main flowering discs, due to genetic differences between hybrids and their ability to adapt to environmental conditions, which affected their growth and productivity. (Alt et al. 2001; Abou El-Magd et al. 2005; and Hanaa et al. 2010) reached similar results. In the context of the two-way interaction between planting dates and hybrids, it was found that planting date 1/9 with Wisdom hybrid achieved the highest total yield of main flowering discs, reaching 64.81 tons ha^{-1}, while planting date 30/9 with Hana hybrid was the lowest, reaching a total yield of 37.25 tons ha^{-1}

Table 9. Effect of planting dates, hybrids and the interaction between them on the total yield of tubers (ton ha^{-1}) of three broccoli hybrids.

Date of planting × Hybrid	Hybrid			
	Wisdom Hybrid (V_1)	Hana Hybrid (V_2)	Hapa Hybrid (V_3)	Mean
1st September (D_1)	64.81	58.33	61.24	**61.46**
15th September	60.32	39.75	59.74	**53.27**

(D_2)				
30th September (D_3)	54.67	37.25	39.99	**43.97**
Mean	59.93	45.11	53.66	
	Date of transplanting	Hybrid	Date of transplanting × Hybrid	
$LSD_{0.05}$	1.231	0.854	1.819	

3.2 Results of ANOVA

Analysis of Variance (ANOVA) serves as a strong statistical method which determines whether multiple groups contain meaningful variations between their mean values. The researchers carried out a split-plot ANOVA to study how different planting dates influenced growth and yield of three broccoli hybrids (Brassica oleracea var. italica). The research examined two major factors including Factor A through its broccoli hybrid variants WISDOM, HANA and HAPA combined with Factor B which consisted of planting dates at September 1st, September 15th and September 30th. ANOVA results help determine if the combination of broccoli hybrids with planting dates shapes crop outcome and if hybrid and planting date synergy impacts yield outcomes. By analyzing variance.

Table 10. ANOVA result

	S.O.V.	d.f.	S.S	M.S.	F	F 0.05
whole plot	Factor A	2	4682.498	2341.249	0.020	3.55
	Error a	18	2074541.523	115252.307		
split plot	Factor B	2	8076.663	4038.332	9.972	3.26
	Factor A * Factor B	4	158.174	39.543	0.098	2.63
	Error b	36	14579.024	404.973		
	Total	62	2102037.882			

Factor A: is Broccoli hybrids with three levels (WISDOM (V_1), HANA (V_2), and HAPA (V_3)), and Factor B; is Date of planting with three levels (1st September (D_1), 15th September (D_2), and 30th September (D_3).

The ANOVA results in table 10 indicate that the choice of broccoli hybrid (Factor A) does not significantly impact growth and yield, as the F-statistic (0.020) is much lower than the critical F-value (3.55). This suggests that among the three hybrids (WISDOM (V1), HANA (V2), and HAPA (V3)) there is no statistically significant difference in their performance. However, the planting date (Factor B) has a highly significant effect on broccoli growth and yield, with an F-statistic of 9.972, which is greater than the critical F-value of 3.26 at a 5% significance level. This confirms that the timing of planting plays a crucial role in determining broccoli yield. The interaction between broccoli hybrids and planting dates (Factor A * Factor B) is not significant (F = 0.098, below the threshold of 2.63), meaning that the effect of planting dates is consistent across all hybrid varieties. The error variance in the whole plot (M.S. = 115,252.307) is substantially higher than in the split-plot (M.S. = 404.973), indicating larger variability among whole plots, possibly due to environmental factors or uncontrolled

variation. In conclusion, the study highlights that selecting the appropriate planting date is more critical for optimizing broccoli growth and yield than choosing a specific hybrid variety.

4. CONCLUSIONS

This study, conducted during the 2024/2025 season at Kalar Horticultural Station in Sulaymaniyah, Iraq, evaluated three broccoli hybrids (Wisdom, Hana, Hapa) at three planting dates (September 1, 15, and 30) to identify optimal practices for maximizing yield and quality. Using a complete randomized design, the study aimed to determine the optimal planting time and best-performing broccoli hybrids to maximize growth, yield, and quality under the climatic conditions of the South of Sulaymaniyah Governorate. Through rigorous experimentation using a complete randomized design, various planting dates and hybrid interactions were evaluated based on key vegetative and yield traits. The findings promote sustainable practices, enhance food security, and improve farmer incomes under local agroclimatic conditions. The results show that the earliest planting date (September 1st) consistently led to the best plant growth, including greater height, leaf count, leaf area, and chlorophyll content. Early planting allowed broccoli to benefit from optimal temperature and sunlight, enhancing vegetative vigor. Among hybrids, Wisdom (V1) exhibited the strongest growth, followed by Hana (V2), while Hapa (V3) performed the lowest. Wisdom's superior adaptability likely contributed to better nutrient uptake and photosynthesis. Yield traits also favored early planting, with the highest flower disc diameter and total yield recorded for the September 1st planting, particularly for the Wisdom hybrid. Statistical analyses confirmed the significant impact of planting date and hybrid selection on growth and productivity. Organic manure, proper soil preparation, and drip irrigation further supported optimal outcomes. Finally, early planting and hybrid selection are crucial for maximizing broccoli production in South Sulaymaniyah. The Wisdom hybrid planted on September 1st proved most effective, offering valuable insights for local farmers and policymakers to enhance cultivation practices.

5. REFERENCES

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