The Impact of Potassium Fertilizer Levels and the Method of Addition on the Growth and Yield of Cauliflower Plants Brassica Oleracea var. Botrytis

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Abstract. The research was conducted at the Agricultural Research Station of the College of Agriculture, University of Basrah, in Karma Ali during the winter agricultural season 2022-2023. The objective of the study was to investigate the impact of the addition of potassium fertilizer at varying levels (0, 100, 200.300) kg ha^{-1}, as well as two methods of sprinkler and ground application on the plant growth and yield of hybrid cauliflower. Flake of white color. The results indicated that the dry weight of vegetative growth, the weight of the flower disc, and the total yield were significantly surpassing the fertilizer level of 200 kg ha^{-1}. Additionally, the percentage of total soluble minerals in the discs was significantly surpassing all levels. The foliar addition resulted in a significant increase in the number of leaves, leaf area, dry weight of vegetative growth, the diameter of the flower disc, its weight, and the total yield. Similarly, the ground addition increased the percentage of dry matter in the flower discs. The interaction between the two factors had a significant impact on the majority of the studied traits. The plants that were sprayed with potassium fertilizer at a level of 200 kg ha^{-1} achieved the highest weight of the disc and the total yield, which were 2.180 kg and 59.95 tons ha^{-1}, respectively.

Keywords. Cauliflower, Potassium Fertilizer, Soil.

1. Introduction

Cauliflower Brassica oleracea var.botrytis is an important winter vegetable crop belonging to the Brassicaceae family. It is grown for its curd, which is the edible part of the plant. It is the flower buds before they open, with the fleshy, enlarged flower stalks [1]. It is considered to have a high nutritional and medical value due to its content of vitamins (B6, B5, K, C), fiber, folic acid, and minerals (P, Mg, Fe, Zn, K) [2]. It also contains polyphenolic antioxidant compounds [3]. The area planted with cauliflower in Iraq for the year 2020 is estimated at about 4,500 dunums with a total productivity of 12,400 tons and a production rate of 2.724 tons. $dunum^{-1}$ [4]. In order to help increase production per unit area, attention must be paid to agricultural service operations, including the fertilization process, due to the nutrients it provides to the plant by determining its type, quantity, and method of addition. One of the most important nutrients that the cauliflower plant needs, which ranks second to the plant, is potassium K [5] for its important role in many vital activities such as photosynthesis, protein metabolism, enzyme activity, regulation of cell osmotic potential, expansion, and thickening of its

walls [6,7]. It is a carrier and activator of many enzymatic activities and is responsible for the process of opening and closing the stomata through its effect on the guard cells located around the stomata, so it controls the level of gas and water exit from During the stomata [8]. [9] concluded that when Brassica napus rape plants were sprayed With potassium sulphate (K 42%) at concentrations (0, 1500, 300, 4500) mg K L^{-1}, the concentration of 4500 mg K L^{-1} caused a significantly excelled in the number of fruits, seed weight and seed yield for both seasons of the experiment.[10]explained that spraying cauliflower plants, White cloud cultivar, with potassium nitrate KNO_3 at different concentrations (2, 1, 0)%, the concentration of 2% was significantly excelled in increasing the number of leaves, weight of the inflorescence without leaves and the total yield compared to the control treatment for both seasons of the experiment [11]. noted that when adding potassium fertilizer at different levels to Paraiso hybrid broccoli plants (300, 200, 0) kg ha^{-1}, the level of 300 kg ha^{-1} was significantly higher in increasing plant height, leaf area, total yield, and percentage of dry matter in the flower disc compared to the control treatment. [12] indicated that adding potassium sulfate fertilizer to cowpea plants at levels (0, 43, 86, 129) kg ha^{-1} led to an increase in plant height, leaf area, number of pods, number of seeds per pod, plant yield, and total yield. [13]. showed that spraying Nahar hybrid cauliflower plants with high potassium fertilizer at different concentrations (3, 1.5, 0) ml L^{-1} caused both concentrations to significantly increase the number of leaves, leaf area, flower disc weight, total yield and percentage of dry matter in the flower disc compared to the control treatment. [14] noted that when spraying Galaxy and Durra hybrid cauliflowers with different concentrations of potassium humate (5, 2.5, 0) g $L^{-1,}$ both concentrations caused a significant increase in the number of leaves, leaf area, flower disc weight and total yield compared to the control treatment. [15] indicated that spraying Organza hybrid cauliflower plants with different concentrations of potassium (4, 2, 0) g L^{-1}, the concentration of 4 g L^{-1} caused a significant increase in the number of leaves, fresh and dry weight of plant leaves, flower disc diameter and yield. Total compared to control treatment. The study aims to find the best method and the best level of addition of potassium fertilizer added either by irrigation in the soil or spraying on the green group and the interaction between them in the growth and yield of the White Flake cauliflower hybrid grown under the conditions of Basra city.

2. Materials and Methods

The experiment was conducted at the Agricultural Research Station - College of Agriculture - University of Basra located in Karmat Ali area during the agricultural season 2022-2023 AD to study the effect of different levels of potassium fertilizer in the form of N:P: K (0:0:40) on the growth and yield of cauliflower, White flake cultivar. The experiment included two factors: the first factor was adding potassium fertilizer at levels of 0, 100, 200 and 300 kg K ha^{-1}, and the second factor was the method of adding potassium fertilizer, as the concentrations were added in two ways: the first was spraying on the plant and the other was a ground addition. The experiment was designed as a factorial experiment with a randomized block design (R.C.B.D) and with three replicates to make the number of experimental units 24 units. The land was prepared by plowing it twice perpendicularly to a depth of 0.4 m and was well smoothed after carrying out the adjustment and leveling operations. The cultivation was carried out on two rows, the distance between each row was 1 m and the width of the row was 0.5 m. The soil was fertilized with animal manure (cow waste) at a level of 5 tons ha^{-1} at a depth of 0.2 m. The rows were divided into three sectors, each containing one replicate of the experimental treatments (24) experimental units, so that the length of the experimental unit was 2 m, and each experimental unit contained 5 plants, and the distance between one plant and the next was 40 cm. Broccoli seedlings (White flake) were grown in plastic plates and then transferred to the ground after reaching the stage of three true leaves. The experimental units were fertilized with nitrogen fertilizer (urea 46% N) at a rate of 250 kg N ha^{-1} and phosphate fertilizer (superphosphate) at a rate of 65 kg P ha^{-1}. Some vegetative growth indicators were estimated such as plant height, number of and leaf area was calculated according to [16]. The fresh weight of the vegetative mass (kg), the dry weight of the vegetative mass (g), the yield and its components were estimated such as the weight of the flower disc (g), the diameter of the flower disc (cm), and the total productivity of the flower discs (tons.ha^{-1}). The total yield was calculated as follows: yield per plant (kg) × plant density/plant. ha^{-1}. Some qualitative and chemical traits were also estimated such as the content of the flower discs of total chlorophyll and carotene (mg/100g^{-1} fresh weight) according to the method described by [17] and

the percentage of total soluble solids in the flower discs. The percentage of dry matter in the flower discs was also estimated.

Table 1. Some chemical and physical properties of the study soil.

Traits		Values	Units
pH		7.7	
Electrical conductivity EC		5.22	dS m-¹
Available phosphorus		38.3	mgkg-¹
Total nitrogen		0.23	gkg-¹
Available potassium		101.20	mgkg-¹
dissolved positive ions	Calcium	16.5	mmol L-¹
	Magnesium	11	
	Sodium	21.3	
dissolved negative ions	Carbonates	0.00	
	Bicarbonates	13.6	
	Sulphates	18.5	
	Chlorides	28.0	
Soil separators	Sand	593	g kg-¹
	silt	271.5	
	Clay	135.5	
Texture		Sandy loam	

leaves.plant^{-1}, total leaf area/plant (dm^2), The results were analyzed statistically using the statistical program GenStat according to the adopted design, and the results were compared to the arithmetic averages according to the least significant difference test at a significance level of 0.05.

3. Results and Discussion

It is clear from Table (2) that the levels of potassium fertilizer have significantly affected the number of leaves and the fresh and dry weights of the plant, but had no significant effect on the plant height and leaf area, as the level of 300 kg ha^{-1} was significantly excelled in increasing the number of leaves compared to the levels of 100, 200 kg ha^{-1}, with an increase rate of (14.70, 23.18), respectively, and did not differ significantly in control treatment, while the level of 100 kg ha^{-1} was significantly excelled in increasing the fresh weight of the vegetative group compared to the level of 300 kg ha-1, with an increase rate of 57.34% It did not differ significantly with control treatment and the level of 200 kg ha^{-1}, while the dry weight of the vegetative group was significantly excelled to the level of 300 kg ha^{-1} compared to control treatment and the level of 100 kg ha^{-1}, with an increase rate of (99.05 ,102.49)% respectively and did not differ significantly with the level of 200 kg ha^{-1}. The significantly excelled of potassium fertilizer levels may be due to the role of potassium in growth and control of important physiological activities for plant growth, including controlling the opening and closing of stomata, carbohydrate formation and regulating water balance in leaves [18]. These results are consistent with what was obtained by [15]. The same table shows that foliar addition caused a significant increase in the number of leaves, leaf area and dry weight of the vegetative group compared to ground addition, with an increase rate of (45.25, 13.12, 7.24)% respectively, and the method of addition did not have a significant effect on plant height and fresh weight of the vegetative group. The significant increase may be due to adding fertilizer as a spray on vegetative growth, as it makes its absorption by the leaves easier and faster, and thus the direct benefit from the potassium element, which works to stimulate enzymes specific to vital activities such as photosynthesis, and also helps in the movement and transfer of food manufactured in the leaves to other plant tissues [8] and increasing the readiness and absorption of necessary nutrients such as nitrogen, phosphorus and potassium from the soil to the plant, which leads to an increase in vital activities in the plant, which is positively reflected in growth [19,20]. The interaction between the two factors showed a significant effect on the traits under study, with the exception of plant height, as plants sprayed with potassium at a level of 300 kg ha^{-1} gave the highest values for the number of leaves, leaf area and dry weight of the vegetative group, which reached (23.0 leaves, 74.3 dm^2, 147.7 g), respectively, while plants sprayed at a level of 100 kg ha^{-1} gave the highest fresh weight of the group. The vegetative mass reached 1.776 kg. While the lowest number of leaves per plant was at the level of 100 kg ha-1, reaching 15.67 leaves. The lowest leaf area and fresh weight of the vegetative mass when adding potassium fertilizer to the

ground at the level of 300 kg ha^{-1}, reached (20.7 dm^2, 0.668 kg), respectively, and the lowest dry weight of the vegetative growth in plants sprayed at the level of 100 kg ha^{-1} reached 35.9 g.

Table 2. Effect of potassium addition level, addition method and interaction between them on some vegetative growth indicators of cauliflower plant.

Treatments			Plant height (cm)	Number of leaves	Leaf area dm^2	Fresh weight of vegetative growth (g)	Dry weight of vegetative growth (g)
Average effect of potassium fertilizer levels kg ha^{-1}	0		63.5	19.19	46.2	1.282	52.1
	100		57.5	15.83	51.8	1.361	53.0
	200		64.3	17.00	44.6	1.104	99.5
	300		61.3	19.50	47.5	0.865	105.5
LSD 0.05			NS	1.65	NS	0.363	10.5
Average effect of adding method	Foliar		62.1	18.5	55.1	1.224	91.8
	Ground		61.2	17.25	39.9	1.082	63.2
LSD 0.05			NS	1.17	6.9	NS	7.4
The effect of the interaction between the adding levels and the addition method	0	Foliar	60.7	17.33	38.5	0.840	45.7
		Ground	66.3	21.00	53.9	1.725	58.5
	100	Foliar	59.0	15.67	57.4	1.770	35.9
		Ground	56.0	16.00	46.3	1.011	70.1
	200	Foliar	71.0	18.00	50.3	1.282	138.0
		Ground	57.7	16.00	38.6	0.925	61.0
	300	Foliar	57.7	23.00	74.3	1.062	147.7
		Ground	65.0	16.00	20.7	0.668	63.4
LSD 0.05			NS	2.34	13.9	0.514	14.9

Table (3) shows that the levels of potassium fertilizer significantly affected the weight of the flower disc, the total yield, and the percentage of total soluble solids in the disc, where the level of 200 kg ha^{-1} significantly excelled the increase in the weight of the flower disc and the total yield compared to the control treatment and the levels of 100 and 300 kg ha^{-1}, with an increase rate of (29.45, 26.50, 84.28)% for each, respectively. The levels did not significantly affect the diameter of the flower disc and the percentage of dry matter in it. The significantly excelled of the level of 200 kg ha^{-1} may be due to the level of 200 kg ha^{-1}, as it is the best level that achieved a significant increase in the dry weight of the vegetative group (Table 2) as a result of the accumulation of manufactured nutrients as a result of adding potassium at the appropriate level and its important role in the process of photosynthesis through controlling the mechanism of opening and closing the stomata, which is directly related to the collection of potassium and sugars in the guard cells [18,21] and its work in improving the process of transporting nutrients. It is manufactured in the leaves to other storage sites in the plant [22] and stimulates enzymes associated with the process of transferring energy necessary to metabolize CO_2 and in building sugars, starch and proteins, as ATP is the main energy carrier [7]. These results are consistent with [10,11,13,14,15]. It appears from the same table that the addition method has a significant effect on all the traits under study, except for the percentage of total soluble solids in the flower disc, as the foliar addition achieved a significant increase in the diameter of the flower disc, its weight, and the total yield, with an increase rate of (35.84, 35.84, 48.32)%, respectively, while the ground addition was significantly excelled in the percentage of dry matter in the disc, with an increase rate of 12.09%. The significantly excelled of the foliar addition may be due to its positive role in increasing the vegetative growth indicators represented by the number of leaves, leaf area, and dry weight of the vegetative group (Table 2), which was positively reflected in increasing the diameter of the flower disc, its weight, and the total yield. As for the increase in the percentage of dry matter in the flower disc when adding potassium fertilizer to the ground, which stimulated the plant to build a root system with high efficiency in absorbing nutrients from the soil, which encouraged the process of photosynthesis and thus increased its nutritional products in the leaves such as carbohydrates and proteins and their transfer to the discs, which leads to an increase in the percentage of dry matter in them. The interaction between the two study factors showed a significant effect in all the studied traits except for the percentage of dry matter in the disc, as the plants sprayed at the level of 300 kg ha^{-1} gave the largest diameter of inflorescence disc and the highest percentage of total soluble solids, which amounted to (23.66 cm, 5.8%), respectively. The plants sprayed at the level of 200 kg ha^{-1} gave the highest weight of inflorescence disc and the total yield, which amounted to (2.180 kg, 59.95 tons ha^{-1}),

respectively. While the lowest diameter of inflorescence disc and the percentage of total soluble solids when adding soil at the level of 200 kg ha^{-1} amounted to (12.34 cm, 4.50%), respectively. The lowest weight of inflorescence disc and the total yield in the plants not added potassium fertilizer amounted to (0.823 kg, 22.69 tons ha^{-1}), respectively.

Table 3. Effect of potassium addition level, addition method and interaction between them on some yield traits of cauliflower plant.

Treatments			Inflorescence diameter (cm)	Inflorescence weight kg	Total yield T.ha^{-1}	Dry matter per disc %	Percentage of total soluble solids%
Average effect of potassium fertilizer levels kg ha-1	0		15.15	0.961	26.44	9.56	4.65
	100		15.62	1.400	38.51	10.42	5.35
	200		15.04	1.771	48.70	10.38	5.06
	300		15.13	1.368	37.62	10.64	5.63
LSD 0.05			NS	0.215	3.93	NS	0.34
Average effect of adding method	Foliar		18.20	1.584	43.56	9.67	5.29
	Ground		12.27	1.166	32.07	10.84	5.06
LSD 0.05			1.79	0.152	4.19	0.88	NS
The effect of the interaction between the adding levels and the addition method	0	Foliar	13.15	1.097	30.18	9.12	4.53
		Ground	17.15	0.823	22.69	10.01	4,76
	100	Foliar	18.26	1.651	48.41	9.75	5.20
		Ground	12.99	1.150	31.62	11.09	5.50
	200	Foliar	17.74	2.180	59.95	9.73	5.63
		Ground	12.34	1.362	37.45	11.04	4.50
	300	Foliar	23.66	1.405	38.72	10.07	5.80
		Ground	6.60	1.326	36.52	11.21	5.50
LSD 0.05			3.58	0.305	18.38	NS	0.48

Conclusion

Based on the research, it is determined that in order to enhance the development and productivity of the White Flake hybrid cauliflower plant cultivated in Basra city, it is necessary to apply foliar potassium fertilizer at a rate of 200 kg ha^{-1}.

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