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Article

Effect of vernalization period on growth and yield of broccoli

Harith Hasan Khudhair[1], and Majid Ali Hanshal[2]*
[1] College of Agricultural Engineering Sciences, University of Baghdad
[2] College of Agricultural Engineering Sciences, University of Baghdad
**Corresponding author:majid.a@coagri.uobaghdad.edu.iq*
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ABSTRACT

The experiment was conducted in the fields of the research station (B) of the College of Agricultural Engineering Sciences - University of Baghdad Al-Jadriya in the autumn season of 2022-2021 to study the effect of vermicompost and the vernalization period on the growth and yield of broccoli, The experiment included two factors, the first: fertilizing with organic fertilizer vermicompost (M) with four concentrations (M0) without adding fertilizer, (M1) 0.5 tons of 1 ton.dunams-1, (M2) 1 ton.dunams-1, (M3) 1.5 ton.dunams-1 and the second factor: vernalization period factor (V including V0) without exposure to cold, (4) (V1 days exposed to cold, V2) 8 days exposed to cold, (V3) 12 days exposed to cold and at a temperature of 5°C ±1.The experiment was conducted as a factorial experiment according to the randomized complete block design (R.C.B.D) with three replicates and 16 treatments for each replicate, to be 48 experimental units whose averages were compared using the L.S.D test at a probability level of 0.05. The results were as follows: The treatment without sequencing significantly excelled in the traits of plant height, number of leaves, stem diameter, leaf area, dry weight and leaf content of chlorophyll, While the vermicompost treatment significantly excelled at 12 days in the traits of the flowering date of 50% of the flowering curd of the plants and it reached (81.92) days and the number of days to harvest 50% of the curds was (107.33) days and the number of days to complete the harvesting process was 117.92) days. The curd diameter was (18.41) cm, and the number of secondary curd was 5.04 curd. Plant -1, the main curd yield was 20.45 (ton ha-1), and the total yield was 28.70 (ton ha-1).

Keywords: growth, yield, broccoli

INTRODUCTION

Broccoli (Brassica oleracea var. Italica) is one of the crops of the cruciferous family (Brassicaceae). The original home of broccoli is the Mediterranean region in Asia Minor. It was known by the ancient Romans and Greeks more than 2,700 years ago. Its cultivation spread in Europe in the sixteenth century, and the Italians hybridized it at the beginning of the twentieth century; the cultivation of broccoli was spread by Italian immigrants in the United States after they brought seeds from Europe. Today, it is considered one of the most important vegetables in the United States, Britain, Spain and Italy. However, in recent years, it has been considered

one of the few plants widespread in Iraq using vermicompost in an Integrated Nutrient Management (INM) system for vegetable crops. Vermicompost is slow-release organic manure that contains most of the micronutrients in chelated form, so it provides plants' nutrient requirements for a longer period. It also helps reduce the ratio of N: C and provides nutrients in the form available to plants such as nitrate, phosphorous, potassium, calcium and magnesium, and it also contains a biologically active substance such as plant growth regulators [1] The process of floral induction (vernalization) is one of the methods used to shorten the period for the formation of flowering in a plant, by exposing seedlings or seeds to low temperatures slightly above zero Celsius [2], It can also be defined as a set of biological processes that prepare the plant for flowering by exposing it to low temperatures for a certain period, called the period predisposing to flowering [3]. Nutrition experts have described some fruits and vegetables as magical because their continued consumption helps reduce weight and gives those who eat them a feeling of satiety due to the fiber they contain. Among the most important vegetables is broccoli, one of the promising vegetables and a source of nutrients [4, 5]. Organic waste has become a major research focus due to its threat to modern society's environment and human health. The global production of agricultural waste is more than hundreds of tons annually. A large part of this agricultural waste is disposed of inappropriately or directly incinerated, which leads to an increase in global warming and air pollution [6] Earthworms secrete Vermicast, a food organic fertilizer rich in macro and micronutrients important in plant nutrition and beneficial soil microbes that fix nitrogen and dissolve phosphates such as bacteria and fungi, as well as secrete growth hormones such as auxins, gibberellins and cytokines [7]. Vermicompost is the most common type of fertilizer rich in beneficial organisms. The components of vermicompost dissolve in water, which is easy for the plant to absorb and benefit from. Vermicompost can be added directly to the plant or placed at the bottom of the seed [8, 9], and Keller et al. 2013 showed that environmental gradients in temperature significantly impact the early and delayed flowering of plants. Shortening the period of vegetative growth and pushing plants to early flowering is a set of quantitative and reverse vital processes; plants are prepared for flowering by exposing them to a low temperature for a certain period, and that period is called the thermal period prepared for flowering. Thermo inductive period

MATERIALS AND METHODS

Experiment location: The experiment was conducted in the College of Agricultural Engineering Sciences, Station B - University of Baghdad Jadriya, for the autumn season 2021-2022.

Preparation of the land: The soil of the field designated for the experiment was prepared by tillage, smoothing and leveling it homogeneously. It was immersed in water and solar sterilization, and then the land was divided into three replicates, each including 16 experimental units. The distance between one line and another was 75 cm, leaving 60 cm as an insulator between the units to prevent confusion between the treatments. Then, the drip irrigation system was installed.

Soil analysis: A sample of field soil was taken from several different areas before starting the experiment with a depth of 0)_30 cm in the area of root spread.

Preparing the seedlings and cultivation: The hybrid broccoli F1 Max seeds, produced by Seeds Horti Company, were planted. The seeds were planted on August 17, 2021, in cork dishes that sought 209 eyes in one of the private nurseries in Baghdad and provided the appropriate conditions for the growth of seedlings. After the seedlings reached four to five, Real leaves were transferred to the field on 10/5/2021 and planted on lines of 10 plants in the experimental unit; the distance between one plant and another is 40 cm, and between one line and another is 75 cm.

Study indicators:
Vegetative growth traits: 5 plants were randomly selected from each experimental unit, and markers were set for conducting the required studies as follows:
Plant height (cm): Measure the height of the plant at the end of the season, using a metric tape measure, from the contact of the stem with the soil to the top of the top leaf.
Number of leaves (leaf.plant-1): according to the total number of leaves for each marked plant, the average was calculated for it.
Leaf area (dm2.plant-1): Three leaves of different sizes were taken randomly from each marked plant, and the Digimizer program measured the leaf area according to the following equation: leaf area of a plant (dm2) = area of one leaf (dm2) x number of leaves per plant.
Growth and yield indicators:
The flowering date of 50% of the curds plants (day) was measured by calculating the number of days from sowing the seeds until 50% of the curds appeared for each experimental unit.
Number of secondary curds (curd plant -1): The number of secondary curds (lateral curds) on the main stem of the experimental unit plants until the end of the growing season was calculated and divided by the number of plants in the experimental unit.
The total yield of the main curds (ton ha-1): The total yield of one experimental unit was calculated by calculating the yield of the main curds for each experimental unit and then due to the hectare.

values	units	traits
1.9	$DS.m^{-1}$	**EC . Electrical conductivity**
7.5	———	**pH**
3.6	$g.kg^{-1}$	**Organic matter**
70.0	$mg.kg^{-1}$	**available nitrogen**
13.0		**available phosphorous**
60.0		**available potassium**
110.0	$mg.kg^{-1}$	**Ca+2**
55.0		**Mg+2**
90.0	$mg.kg^{-1}$	**SO4-2**
60.0		**Cl-**
15.0	%	**sand percentage**
49.0		**silt percentage**
36.0		**Clay percentage**
silty clay loam		**soil texture**

Table 1. Chemical and physical properties of soil

The first factor, the vernalization factor, exposing the seedlings to low temperatures for four periods at a temperature of (5) ± 1 ° C ((V0) without exposure to cold, (V 1) four days inside the incubator at a temperature of (5) ± 1 ° C (V2) eight days inside the incubator at a temperature of (5) ± 1 ° C, (V3) twelve days inside the incubator at a temperature of (5) ± 1 ° C.
The second factor is the organic fertilizer (Vermicompost) added to the soil directly during the cultivation of seedlings in the field. The addition was on four levels as follows: (M 0) without the addition of organic fertilizer, (M 1) half of the recommendation of the producing company (0.5) $ton.ha^{-1}$, (M2) the recommendation of the producing company of one $ton.ha^{-1}$ (M3) one And half of the recommendation of the producing company is (1.5) $ton.ha^{-1}$

RESULTS

The effect of vermicompost, vernalization period and interaction between them on vegetative growth traits:

Plant height: The results in Table (4) indicate the treatment of adding organic fertilizers significantly excelled and gave the height of the plant, where the vermicompost M3 treatment (1.5 tons.dunum^{-1}) excelled by recording the highest plant height of 67.16 cm without a significant difference from M2 and compared to the lowest height appeared in treatment M0 and reached 61.38 cm. The treatment of exposure to cold periods significantly excelled on the treatment of V0 by giving the highest plant height of 66.69 cm. It did not differ significantly from treatments V1 and V2 as it gave 64.16 and 64.41 cm compared to the lowest height of treatment V3 (12 days exposed to cold), reaching 63.08 cm. As for the interaction coefficients between the organic fertilizers and the vernalization period, the interaction treatment V2M3 excelled by giving the highest height of 70.00 cm compared to the lowest height of 59.66 cm for treatment V3M0.

Average Fertilizers	vernalization period (V)				(M) Fertilizers
	V3	V2	V1	V0	
61.38	59.66	59.77	61.55	64.55	M0
63.19	62.55	62.22	63.22	64.77	M1
66.61	67.33	65.66	65.11	68.33	M2
67.16	62.77	70.00	66.77	69.11	M3
2.51	5.03				Lsd5%
	63.08	64.41	64.16	66.69	Average vernalization
	2.51				Lsd5%

Table 3. Effect of organic fertilizer, vernalization period and interaction between them on plant height (cm) of broccoli plant for the season 2022-2021

Number of leaves (leaf.plant^{-1}): The results in Table (3) showed that the M3 treatment of vermicompost significantly excelled and gave (1.5 tons . dunam^{-1}) on the rest of the treatments by giving it the highest number of leaves per plant 59.42 leaf.plant^{-1}. As for the lowest number of leaves, it appeared in the M0 treatment, and it was 33.13 leaves. Plant-1. There were significant differences in the effect of the vernalization period, where the treatment (V0) was characterized by the highest number of leaves, which was 46.88 leaves. Whereas the quaternity treatment (V3) gave the lowest number of leaves, which amounted to 42.79. Plant^{-1}. As for the interaction between the vernalization period treatments and the organic fertilizers, there was a significant effect. The treatment of interaction V2M3 significantly excelled by giving it the highest number of leaves, which amounted to 68.00 leaf.plant^{-1}, compared to treatment V3M0, which recorded the lowest number of leaves, reaching 27.33 leaf.plant^{-1}.

Average Fertilizers	(Vvernalization period)				(MFertilizers)
	V3	V2	V1	V0	
33.13	27.33	34.17	35.67	35.33	M0
41.04	42.83	37.00	40.67	43.67	M1
49.83	48.83	52.17	48.83	49.50	M2
59.42	52.17	55.00	58.50	59.00	M3
1.46	2.92				LSD 5%
	42.79	44.58	45.91	46.88	Average vernalization
	1.46				LSD 5%

Table 3. Effect of vernalization period and organic fertilizer and the interaction between them on the number of leaves (leaf.plant^{-1}) of broccoli plant for the season 2022-2021

3.1.3. Leaf area (dm^2 $plant^{-1}$): The results in Table 4 show the treatment of organic fertilizer vermicompost. The M3 treatment (1.5 tons $dunum^{-1}$) significantly excelled over the rest of the treatments in the aspect of leaf area, which amounted to 101.65 dm^2 $plant^{-1}$) in the recorded M0 treatment (without adding fertilizer) had the lowest leaf area and amounted to 64.48 dm^2 $plant^{-1}$). The treatment without exposure to cold, V0, excelled on the rest of the treatments by giving the highest leaf area (95.73 dm^2 $plant^{-1}$), while the V3 treatment recorded the lowest leaf area (63.02 dm^2 $plant^{-1}$). From the results of the same Table, we find that the interaction treatment V2M3 gave the highest leaf area and no significant difference from the treatment V1M3 and the results were (124.80 and 124.30 dm^2 $plant^{-1}$) respectively, while the treatment V3M0 recorded the lowest leaf area amounted to 56.20 dm^2 $plant^{-1}$)

Average Fertilizers	**(Vvernalization period)**				**(MFertilizers)**
	V3	V2	V1	V0	
64.48	56.20	65.80	69.80	66.13	M0
71.30	60.20	70.30	77.40	77.30	M1
93.20	70.50	78.20	109.20	115.20	M2
101.65	71.20	124.80	86.30	124.30	M3
5.86	11.72				LSD 5%
	63.02	84.77	85.67	95.73	Average vernalization
	5.86				LSD 5%

Table 4. The effect of organic fertilizer and the vernalization period and interaction between them in leaf area (dm^2 $plant^{-1}$) for broccoli plant for the season 2021-2020

Effect of vermicompost, vernalization period and the interaction between them on yield traits:

Flowering date of 50% of the flower discs (day)

The results in Table (5) indicated significant differences between the treatments of the organic fertilizer vermicompost used in the days required for 50% of curd to appear. It is noted that treatment M3 excelled, where it gave the least number of days and amounted to 90.83 days compared to treatment M0, where the number of days was 101.33 days, until the effect of the treatment period of lactation, a clear effect appeared for the treatment of vernalization V3 (12 days exposed to cold)As this treatment proceeded early with the fewest number of days, it amounted to 81.92 days, compared to the treatment V0 (without vernalization), which took 102.50 days to give 50% of flowering curd, 77.33 days. It significantly excelled on all the treatments, while the treatment V0M0 took the most days and amounted to 108.00 days.

Average Fertilizers	**(Vvernalization period)**				**(MFertilizers)**
	V3	V2	V1	V0	
101.33	87.33	103.33	106.67	108.00	M0
91.92	80.67	84.33	105.33	103.00	M1
92.17	82.33	94.67	88.67	97.33	M2
90.83	77.33	94.33	90.00	101.67	M3
1.90	3.80				LSD5%
	81.92	94.17	97.67	102.50	Average vernalization
	1.90				LSD5%

Table 5. Effect of organic fertilizer, vernalization period and interaction between them on the flowering date of 50% of the flowering curd of broccoli for the season 2022-2021

The number of lateral curd(curd .plant^{-1}):

It is clear from Table 15 that the effect of the M3 organic fertilization treatment excelled by giving it the largest number of lateral curd in the plant, which was 5.08. Plant-1 did not differ significantly from M2 treatment, while treatment M0 gave the lowest number for curd was 3.77 curd.plant^{-1}. The results of the vernalization period treatment indicated this trait, where the M3 treatment excelled by giving it the largest number of secondary curds, which amounted to 5.04 curd .plant^{-1}, which differed significantly from the rest of the treatments. While the control treatment M0 gave the lowest number of lateral curd, which was 4.25 curds.plants^{-1}.As for the effect of the interaction, the results showed that treatment V3M1 excelled, giving 5.75 curd.plant^{-1}, while treatment V0M0 compared the treatment that gave the least number of curds, which amounted to 3.21 curds.plant^{-1}.

Average Fertilizers	**(Vvernalization period)**				**(MFertilizers)**
	V3	V2	V1	V0	
3.77	4.08	3.75	4.05	3.21	M0
4.44	5.75	3.88	4.38	3.75	M1
4.84	5.13	5.00	3.83	5.42	M2
5.08	5.21	5.17	5.33	4.63	M3
0.30	0.60				LSD 5%
	5.04	4.45	4.40	4.25	المتوسط
	0.30				LSD 5%

Table 6. Effect of feeding period and organic fertilizer and the interaction between them on the number of secondary flowering curd of broccoli for the season 2022-2021

The yield of the main plant curd (ton ha^{-1}):

The results in Table 6 show the ground application of vermicompost V3 excelled in the plant yield amounted to 20.40 tons ha^{-1}. Whereas treatment M0 gave the lowest yield of the plant, amounting to 15.93 tons ha^{-1}. The results indicate that the vernalization period treatments, where treatment V3 excelled on the rest of the treatments in increasing the yield of the main curd of the plant, amounted to 20.45 tons ha^{-1}, which differed significantly from the rest of the treatments. In comparison, the treatment V0 recorded the lowest yield plant, which amounted to 17.79 tons ha^{-1}. The results also indicate that the addition of organic fertilizer had a significant effect on the yield of the main curd of broccoli, as for the interaction treatments between organic fertilizers and cold treatments, the interaction treatments had a significant effect on the yield of the main curds. The treatment V3M3 was characterized by giving the highest yield of the plant, amounted to 24.00 tons ha^{-1} and differed significantly from the rest of the treatments. The treatment V2M0 recorded the lowest yield, which amounted to 15.90 tons ha^{-1} and did not differ significantly from the control treatment V0M0, which gave 15.93 tons ha^{-1}.

average Fertilizers	(Vvernalization period)				(MFertilizers)
	V3	V2	V1	V0	
17.28	17.89	15.90	19.43	15.93	M0
18.10	18.98	18.51	16.83	18.08	M1
19.46	20.95	19.46	19.03	18.43	M2
20.40	24.00	20.46	18.43	18.73	M3
0.80	1.61				lsd5%
	20.45	18.58	18.43	17.79	Average vernalization
	0.80				lsd5%

Table 7. The effect of organic fertilizers, vernalization period and the interaction between them on the yield of the main curd (ton ha^{-1}) of broccoli plant for the season 2021-2020

DISCUSSION

From this, it is clear that the cold treatment led to a reduction in plant growth compared to all other treatments due to the role of cold in reducing enzymatic reactions within the plant, which was reflected in the metabolic reactions and the general growth of the plant [10]. This is due to the rush of plants that were exposed to low temperatures to flowering the flower induction process and the early cessation of vegetative growth, which reduced the number of leaves (Table 3). This was reflected in the leaf area (Table 5), while control plants continued vegetative growth, which increased the number of leaves, causing an increase in the leaf area [11]. It agrees with his finding [12] in studying the effect of plant age and vernalization periods on garlic plants. Previous studies also indicate that photosynthesis and growth were significantly reduced under cold stress. In previous studies, cold stress was reported to reduce auxin transport and thus restrict plant growth [13]. It is noted from Table (4,3,2) the effect of using vermicompost on the traits of plant height, number of leaves and leaf area. The organic fertilizer vermicompost may also affect the vegetative traits because it improves the physical and fertility traits of the soil, such as increasing the moisture content of the soil. It can retain water, increase the porosity of the soil, work to ventilate it and increase minerals and nutrients. Vermicopost is also characterized by being fast soluble in water, which makes it easier for the plant to absorb nutrients and benefit from them. It is also rich in humic substances and growth hormones such as auxin, gibberellin and cytokinin. This was confirmed by [14] as it works to increase the division of the developing apex cells, and this is reflected positively on the growth of the plant, as well as its richness in beneficial microorganisms such as bacteria and fungi, and this makes it suitable for plant growth and this is in agreement with Tomati et al. (1988) [15].

The process of transition from the vegetative phase to the reproductive phase is considered one of the important processes in the growth and development of high-end plants, which are largely exposed to environmental and genetic influences [16], which refer to early maturity, The results of tables (4,5,6) show the moral effect of the vernalization process in reducing the number of days from seedling until the appearance of the first pink disc and the harvesting date for 50% of curd of the experimental unit and the completion date of the harvesting of the experimental unit. The reason for this may be due to the vernalization process, which leads to genetic changes at the level of the cytoplasm that lead to a change in gene expression at the level of regulating the work of the gene, regulating the action of enzymes or regulating plant hormones, which leads to changes at the level of the cell and the growth of plant tissues [17]. The effect of the vernalization process on the above traits may be because the endogenous hormones, especially gibberellins, have an effect on encouraging the flowering process. Low temperatures stimulate

the formation of gibberellins and thus urge plants to flower, while the increase in temperature hinders the formation of gibberellins and thus reduces the flowering of plants [18]. Perhaps the reason for the excellence of the follow-up treatment over the control treatment is in the trait of the total yield, kg.ha^{-1}, in contrast to the vegetative and flowering traits. The yield traits of one plant may lead to an increase in the percentage of flowering plants, which leads to an increase in the production of unit area, and an increase in the percentage of flowering plants may be due to the genetic stimulation of the phenomenon of quartiles [19].

CONCLUSION

It is noted from the above the importance of using various organic fertilizers, especially vermicompost, in the cultivation of vegetable crops, which are environmentally friendly and cheap materials and have an important role in reducing the percentage of chemical addition because of their negative and noticeable negative effects in environmental pollution and harm to humans and animals.

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