Effect of Mulching Type on Growth and Yield of Two Cauliflower Varieties (*Brassica Oleracea* L. Var. *Botrytis*)

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Abstract. A field experiment was conducted in the research station of the Horticulture and Landscape Department, College of Agriculture, Tikrit University; to study the effect of mulch type on the growth and yield of two varieties of cauliflower during the 2017 – 2018 season. The experiment was carried out according to the split -plot layout within Randomized Complete Block Design (RCBD) and three replicates. Mulch types; black and yellow polyethylene in addition to the control treatment (non-mulch) were in the main plots, and varieties of cauliflower (Fuji Yama and White Cloud) were placed in sub-plots. Means were compared using Duncan multiple range test at 5% probability level. Results showed that there were no significant differences between mulching types in plant height, curd weight, curd length, and shoot weight. Meanwhile, there were significant increases in the number of leaves, leaf length, stem weight, compared with control. Curd diameter and chlorophyll contents increased significantly under black polyethylene mulching compared with both yellow mulching and control. On the other hand, there was no significant difference between the two varieties in all studied vegetative and yield parameters except leaf length which showed a significant increase with White Cloud variety (31.778 cm) compared with Fuji Yama (29.926 cm). The interaction between black mulching and White Cloud variety was significantly superior in the number of leaves (18.333 leaf.plant⁻¹), plant height (8.083 cm), leaf length (34.556 cm), and chlorophyll contents (45.567 SPAD). The interaction between black mulching and Fuji Yama variety gave a significant increase in curd diameter (17.500 cm). Meanwhile, the treatments did not show any significant change in other characteristics of plants.

1. Introduction

Cauliflower *Brassica oleracea* var. botrytis is a cool season crop and one of the most important winter vegetables due to its high nutritional value and contains many important nutrients such as vitamins C and E, magnesium, iron, zinc, sodium, calcium, and high quality proteins [1]. The most important using part in this plant is the curd which is sometimes called "head". It is used as cooked or boiled and in the pickles industry. Each 100 g of the curd contains: 9-10 g moisture, 27 calories, 2.7 g protein, 0.2 g fat, 5.2 g carbohydrate, 0.1 g fibre, 0.9 g water, 25 mg calcium, 56 mg phosphorus, and 1.1 mg iron, as well as vitamin A and ascorbic acid [2].

Cauliflower considers as an annual herbal plant with some varieties sometimes, and biannual in other varieties. This plant grows in two stages like other several vegetable plants in this family (Brassicaceae), vegetation growth in the first stage and flowering (flowers formation) in the second stage.

Statistics of [3] refers that planted areas in cauliflower decreased in the last decade in the Middle East, but at the same time, there is an increase in production. This rising in yield has been achieved due to the use of many different factors that reflected positively on the production of cauliflower plants. In general, the variability in the production of cauliflower depends on several factors including genotypes and the environmental conditions during the grown period, chemical and organic fertilizer, age of the plant, mulching, and many other factors [4].

Mulching generally and polyethylene mulching (inorganic mulch) in particular have become one of the important agricultural applications in the commercial production of vegetables in most parts of the...
world. It has been stated that plastic mulch which is available in various types and colours, has a different effect on soil conditions, which further affects plant growth and yield. It is used to increase yield and improve the quality of produce by reducing water consumption, regulate soil temperature, protect roots in freezing weather, improve the physics characteristics of soil, and increase CO₂ and nitrogen concentration in soil. Also, it is used to improve soil structure, reduce soil erosion, enhancing organic matter content, and to avoid bush and weeds, or for other agricultural benefits [5,6,7]. Also, it has been reported that mulching plays an important role in reduce salt concentration of soil in both directions, vertically and horizontally [8]. Accordingly, as an example, 9000 hectares are grown to produce peppers in Australia using polyethylene mulching [9]. Conducted [10] a study on the strawberry to know the effect of black polyethylene, clear polyethylene, straw and the plant's remains. They found that the soil temperature was higher with mulch by black and clear polyethylene treatments compared with other types of polyethylene. Also, they found out that plastic mulching regulated the temperature to a depth of 30 cm of soil and was the most regular temperature at depth 0-15 cm, and this is well suited to the effective depth of the roots of cauliflower.

The effect of intrinsic factors has mostly been attributed to difference and aging. Furthermore, the genetic variants produce the same quantity and quality of yield if grown together. This result exemplifies the concept that environmental and spatial factors are stronger than the genetic variation factor in their effect on plant production, both qualitative and quantitative [11].

However, [7] found in his study about the effect of mulching on two cauliflower varieties that yellow polyethylene mulching gave the highest plant height, curd length, and curd weight compared with non-mulching treatment. Meanwhile, black polyethylene mulching distinguished significantly with the number of leaves and total yield. On the other hand, he explained the non-significant effect of different varieties on growth and yield characteristics [12].

It is believed that just different species can present variable responses to hormones application, their response could be in different ways according to the plant's development stage and number of hormone application. This experiment aimed to understand the distribution of genetic variation between and within populations in a crop of two varieties. Also, it tested the response of different varieties of cauliflower plants to different types of mulches.

2. Materials and Methods:
The experiment has been conducted in the research station fields of the Department of Horticulture and Landscape, College of Agriculture, Tikrit University for the agricultural season of 2017-2018, and contents two factors:
1. Mulching: by using two types of polyethylene and compared with plants grown without any mulching.
   A: Black mulching
   Y: Yellow mulching
   C: non-mulching
2. Varieties: by use two kinds of cauliflower varieties:
   V1: Fuji Yama
   V2: White Cloud

The plants have been prepared on 4th September 2017; the seeds were placed in Styrofoam seedling 209 holes (which is most commonly used for seedlings of transplanted plants) filled with compost. On 10th October 2017 when the plants approached 7-10 cm and 5-6 true leaves appeared, the plants transplanted in the field. Seedlings planted in raised-bed lines pattern in the third top with 1 meter length and 40 cm between each plant and 75 cm between each line. The experiment was arranged as a factorial experiment in a Randomized Completely Block Design (RCBD) with two factors was used for the bioassay experiment, which was replicated three times. The first factor was mulching types; two types of mulching applied (black and yellow polyethylene) in addition to treatment without any mulching, used as control. The second factor was two varieties of cauliflower: Fuji Yama and White Cloud. There were six treatments in each replicate as a result of the interaction between polyethylene mulching and two varieties of cauliflower. SAS program was used to analyses variance. Duncan's test at 0.05 probability levels was employed to separate mean values.
Table (1) Physical and chemical characteristics of field soil

| Organic matter (mg. kg⁻¹) | Gypsum (g. kg⁻¹) | EC (Dṣ. M⁻¹) | pH | N (mg. kg⁻¹) | P (mg. kg⁻¹) | K (mg. kg⁻¹) | Sand (g. kg⁻¹) | Silt (g. kg⁻¹) | Clay (g. kg⁻¹) | Textural class |
|-------------------------|------------------|-------------|----|-------------|-------------|-------------|-------------|-------------|-------------|----------------|
|                         | 32               | 0.15        | 46 | 7.9         | 25          | 0.20        | 4.0          | 604         | 233         | 163            | Loamy sand    |

2.2 Measurements:
1- Plant growth
a. Leaves number (leaf plant⁻¹)
b. Chlorophyll content (SPAD)
c. Percentage of leaves dry mass (%)
d. Percentage of curd dry mass (%)
2- Quantity yield characteristics:
a. Total production of curd per area unit (ton ha⁻¹)
b. Mean of curd weight (kg)
3- Quality yield characteristics:
a. Curd diameter (cm) using a meter rule.
b. Curd length (cm) using a meter rule.

3. Results and Discussion:
Table (1) showed that there are no significant differences in stem length, curd weight, curd length, and vegetation weight with different types of mulching. Meanwhile, there was a significant difference in number of leaves noticed with black mulching treatment (B) which gave the highest number of leaves 17.333 leaf plant⁻¹ and leaf length 32.779 cm compared with no-mulching treatment (C) which was 14.167 leaf plant⁻¹ and 28.055 cm respectively. At the same time, the difference between black (B) and yellow (Y) mulching treatments did not differ significantly in both of these characteristics. However, black mulching (B) discriminates significantly in curd diameter 16.833 cm and chlorophyll contents 45.150 SPAD compared with both (Y) and (C) which were 14.708 and 12.833 cm for curd diameter and 37.483 and 32.267 SPAD for chlorophyll contents respectively. On the other hand, (Y) differs significantly by giving the highest stem weight 44.783 g compared with (c) 27.150 g, but this difference was not significant with (B).

Table (2) Influence of types of mulching on some plant characteristics

| Treatments | Leaves number | Stem length (cm) | Leaf length (cm) | Curd weight (g) | Curd diameter (cm) | Curd length (cm) | Vegetation weight (g) | Stem weight (g) | Chlorophyll contents (SPAD) |
|------------|---------------|------------------|------------------|-----------------|-------------------|-------------------|----------------------|---------------|-----------------------------|
| B          | 17.333        | 7.550            | 32.779           | 296.08          | 16.833            | 6.9000            | 327.30               | 38.533        | 45.150                      |
| Y          | 16.750        | 7.125            | 31.723           | 319.87          | 14.708            | 7.4000            | 341.28               | 44.783        | 37.483                      |
| C          | 14.167        | 6.708            | 28.055           | 180.08          | 12.833            | 7.3917            | 204.18               | 27.150        | 32.267                      |

Table (3) illustrates that the varieties of cauliflower did not cause any significant increase in all of the measured characteristics except leaf length with V2 which exceeds by gave superior length (31.778 cm) compared with lowest length (29.926 cm) for V1.

Table (3) Influence of cauliflower varieties on some plant characteristics

| Treatments | Leaves number | Stem length (cm) | Leaf length (cm) | Curd weight (g) | Curd diameter (cm) | Curd length (cm) | Vegetation weight (g) | Stem weight (g) | Chlorophyll contents (SPAD) |
|------------|---------------|------------------|------------------|-----------------|-------------------|-------------------|----------------------|---------------|-----------------------------|
| V1         | 15.50         | 7.061            | 29.926           | 283.67          | 14.805            | 7.466             | 290.11               | 37.278        | 37.078                      |
| V2         | 16.666        | 7.194            | 31.778           | 247.02          | 14.777            | 6.994             | 292.07               | 36.367        | 39.522                      |
Mulching introduces CO₂ to the plant. As known that CO₂ in the root area is very important for the growth of flowering, and maturity of the crop. These results have been consistent with previous studies [16]. In general, it has been concluded that mulching creates an optimum temperature and became a source of soil fertilization, especially in poor nitrogen soils by adding ammonium and nitrate nitrogen [16]. It also reduced the rate of photosynthesis and increased the growth of flowering, and maturity of the crop. These results have been consistent with previous studies [16]. In general, it has been concluded that mulching creates an optimum temperature and became a source of soil fertilization, especially in poor nitrogen soils by adding ammonium and nitrate nitrogen [16].

Likewise, it caused an increase in the rate of carbon dioxide fixation and increased the growth of flowering, and maturity of the crop. These results have been consistent with previous studies [16]. In general, it has been concluded that mulching creates an optimum temperature and became a source of soil fertilization, especially in poor nitrogen soils by adding ammonium and nitrate nitrogen [16]. Also, these results could be due to soil mulching by black polyethylene which caused the rising of soil temperature more than yellow polyethylene and control, and that leads to an increase the activity of soil microorganisms. The interaction between types of mulching and two different varieties showed significant differences among the plants (Table 3). White Cloud plants (V2) mulched by black polyethylene (B) had a significantly higher number of leaves (18.333 leaf/plant⁻¹), stem length (8.083 cm), leaf length (34.556 cm), and chlorophyll contents (45.567 SPAD) compared with other treatments. Whilst, the interaction between kinds of mulching and varieties did not cause any significant increase in terms of the curd weight, curd length, stem weight, and vegetation weight.

Table (4) Influence of interaction between types of mulching and cauliflower varieties on some plant characteristics

| Treatments | Leaves number | Stem length (cm) | Leaf length (cm) | Curd weight (g) | Curd diameter (cm) | Curd length (cm) | Vegetation weight (g) | Stem weight (g) | Chlorophyll contents (SPAD) |
|------------|---------------|-----------------|-----------------|----------------|------------------|-----------------|---------------------|----------------|---------------------------|
| B V1       | 16.333        | 7.016           | 31.00           | 302.8          | 17.500           | 7.100           | 308.8               | 36.667          | 44.733                    |
| Y V1       | 13.833        | 7.166           | 27.22           | 157.5          | 11.833           | 7.433           | 185.8               | 26.167          | 32.100                    |
| C V1       | 16.333        | 7.000           | 31.55           | 390.7          | 15.083           | 7.866           | 377.7               | 49.000          | 34.400                    |
| BV2        | 18.333        | 8.083           | 34.55           | 289.1          | 16.167           | 6.700           | 348.8               | 40.400          | 45.567                    |
| Y V2       | 14.500        | 6.250           | 28.88           | 202.7          | 13.833           | 7.350           | 222.5               | 28.133          | 32.433                    |
| C Y2       | 17.167        | 7.250           | 31.89           | 249.1          | 14.333           | 6.933           | 304.1               | 40.567          | 40.567                    |

Results showed the type of mulching lead to significant differences in some cauliflower characteristics. In this case, the increase in growth caused by mulching could be a result of the effect of mulching provides good conditions of soil temperature and humidity and dissolves weeds [13]. Also, these results could be due to soil mulching by black polyethylene which caused the rising of soil temperature more than yellow polyethylene and control, and that leads to an increase the activity of soil microorganisms improves the physical and chemical soil characteristics. This improvement makes most of the soil elements easier to uptake by the roots of the plants. As well as, the soil microorganisms increased the pH of field soil which was gypsum soil (7.9 pH) and that amend the availability of soil elements [14,15]. Moreover, mulching plays an important role in the development of roots uptake by increase the availability of nutrition and preventing volatilization of soil. Also, prevent weeds and survival them under plastic cover which leads to a decomposition of them and became a source of soil fertilization, especially in poor nitrogen soils by adding ammonium and dioxide nitrogen [16]. In general, it has been concluded that mulching creates an optimum temperature for roots during the growing season, as well as conserving moisture. Likewise, it caused an increase in the rate of photosynthesis which hence growth flowering, and maturity of the crop. These results have got it maybe as a result of reflect of solar radiation to the shaded parts of plants by mulch surface [17]. Mulching introduces CO₂ to the plant. As known that CO₂ represent in root area is very important for the plant in Ion exchange. Also, CO₂ goes out through the plastic cover from the hole under the plant, and that means more available CO₂ to plant using in photosynthesis [4]. These results are in agreement with the literature of [19] in which is observed a similar trend of a higher degree of genetic variation within populations. At the...
same time, the results were partly in agreement with [20]. These authors reported that the content of eucalyptol from rosemary can be variable depending on the environment of the plant.

The interaction between mulching type and different varieties shows significant differences among the plants. These effects of mulching maybe because of maintaining soil from compression, as well as obstruct weeds and save water and relevant temperature for plant roots [21]. On other hand, the differences between plant characteristics could be due to single factors (mulching and two different varieties). [4] stated that mulching plays an important role in salts moving outside of the mulching area. Moreover, yellow mulching performs to attract insects which lead to kill them according to high temperature on the surface of the plastic. As a result, that means mulching produces protection to plants.

4. Conclusion

This study indicated that mulching types caused significant increases in the number of leaves, leaf length, and stem weight. Black polyethylene mulching, increased curd diameter and chlorophyll contents significantly more than yellow mulch. Cauliflower varieties there did no differ significantly in all studied parameters except leaf length which distinguished with White Cloud variety. The interaction between mulching and varieties shows significant differences. It caused an increase in curd diameter, number of leaves, plant height, leaf length, and chlorophyll contents.

References

[1] USDA, 2013, Agricultural research service. National nutrient database for standard reference release 27.
[2] Watt,B K 1963, Composition of foods. Agricultural. Handbook No.8. Washington, DC: U.S. Department of Agriculture.
[3] CSAIT 2010, Central statistical agency and information technology report. Directorate of Agricultural Statistics, Ministry of Planning, Iraq.
[4] Hassan,A A 1998, Technology of vegetable production. Academic Bookshop, Cairo, 1998.
[5] Taylor, H.D, Bastos, R,K,X, Pearson, H,W, and Mara, D,D 1995. Drip irrigation with waste stabilisation pond effluents: Solving the problem of emitter fouling. Water Science and Technology, 31(12), p.417.
[6] Lamont,W J 2005, Plastics: Modifying the microclimate for the production of vegetable crops. Hort. Technology, 15(3), 477-481.
[7] Mohammed,I A 2017. The effect of soil mulching and transplanting date on the growth and yield of two hybrids of cauliflower Brassicaoleracea var Botrytis. Master thesis, Collage of Agriculture, University of Kirkuk, Iraq.
[8] Aljanabi,M A A 2005. Evaluate of drip irrigation for onion Allium cepa L. under using of mulching and manure application in soil. Master thesis, Collage of Agriculture, Anbar University, Iraq.
[9] Olsen,J K, and Gounder, R, K 2001. Alternatives to polyethylene mulch film—a field assessment of transported materials in capsicum (Capsicum annuum L.). Australian Journal of Experimental Agriculture, 41(1), 93-103.
[10] Gupta,R, and Acharya,C L 1993, Effect of mulch induced hydrothermal regime on root growth, water use efficiency, yield and quality of strawberry. Journal of the Indian Society of Soil Science, 41(1), 17-25.
[11] Viuda-Martos, M, Ruiz-Navajas, Y, Fernandez-Lopez, J, and Perez-Álvarez, J, A 2007, Chemical composition of the essential oils obtained from some spices widely used in Mediterranean region. Acta Chimica Slovénica, 54, 921.
[12] Prins,C L, Vieira,I J, and Freitas, S, P 2010, Growth regulators and essential oil production. Brazilian Journal of Plant Physiology, 22, 91-102.
[13] Kirnak,H, Kaya,C, Higgs, D, and Gercek,S 2001, A long-term experiment to study the role of mulches in the physiology and macro-nutrition of strawberry grown under water stress. Australian journal of agricultural research, 52(9) 937-943.
[14] Roe,N E, Stoffella,P J, and Pryan,H H 1994, Growth and yield of bell pepper and minter squash grown with organic acid living mulches. Journal of the American Society for Horticulture Sci. 119, 1193-1199.
[15] Alemam, E A, and Aljubory, A A 2017, Response of two cucumber varieties Cucumis sativus L. to soil mulching by coloured plastics and intermediate of planting effects on growth under non-heated conditions of greenhouse. *Euphrates Journal of Agriculture Science*, **9**(4), 1-22.

[16] Wien, H C, Minoti, P L, and Grudinger, V P 1993, Polyethylene mulch stimulates early root growth and nutrient uptake of transplanted tomatoes. *Journal of American Society for Horticultural Science*, **118**, 207-211.

[17] Sibale, D 2015, Response of cauliflower (Brassica Oleracea L.) to various mulches and irrigation levels under drip irrigation. (Doctoral dissertation, DBSKKV DAPOLI).

[18] Martinetti, L, Quattrini, E, Bononi, M, and Tateo, F 2006, February. Effect of the mineral fertilization on the yield and the oil content of two cultivars of rosemary. In *I International Symposium on the Labiatae: Advances in Production, Biotechnology and Utilisation*, 723, 399-404.

[19] Tawfeeq, A 2017, Factors affecting essential oil production in rosemary (Rosmarinus officinalis L.). Doctoral dissertation, University of Reading, UK.

[20] Socaci, S A, Tofana, M, Socaciu, C, Varban, D, and Muste, S 2007, Comparative study of different rosemary essential oil. *Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Agriculture*, **63**.

[21] Alsabary, M R S 2005, Effect of some agricultural treatments in growth and yield of lettuce. Master thesis, *Collage of Agriculture and Forestry, Mosul University, Iraq.*