Turkish Journal of Agriculture - Food Science and Technology, 11(12): 2314-2322, 2023
DOI: https://doi.org/10.24925/turjaf.v11i12.2314-2322.6284

Turkish Journal of Agriculture - Food Science and Technology

Available online, ISSN: 2148-127X | www.agrifoodscience.com | Turkish Science and Technology Publishing (TURSTEP)

Orange Peel and Cauliflower Residues Supplementation Induce Morphological and Physiological Tolerance in Common Bean under Drought Stress

Elif Sude Çiçek[1,a], İlkay Yavaş[2,a,*]

[1]*Department of Laboratory Technology, Kocarli Vocational High School, Aydın Adnan Menderes University, 09100 Aydın, Türkiye*
[2]*Department of Plant and Animal Production, Kocarli Vocational High School, Aydın Adnan Menderes University, 09100 Aydın, Türkiye*
[*]*Corresponding author*

A R T I C L E I N F O

Research Article

Received : 14.08.2023
Accepted : 19.12.2023

Keywords:
Cauliflower waste
Climate change
Orange peel
Phaseolus vulgaris
Zero waste

A B S T R A C T

Drought is one of the most harmful abiotic stresses affecting the development and yield of the common bean (*Phaseolus vulgaris* L.). The current climate change and the resulting increased drought will worsen the negative impact of water stress on the plant. The powder of orange peel and cauliflower waste were added as soil supplementation at rates of 7 and 15 g/pot to pots of *Phaseolus vulgaris* L. under different drought conditions. The growth and physiological analysis were estimated after flowering period of common bean. In the pots where drought will be applied, irrigation was stopped for 2, 4, 6, 8 and 10 days during the flowering period and irrigation was performed again after water stress application. To measure moisture percentage of pots, first dry pots were weighed and after irrigation, their moisture variation in terms of percent was measured during stress from 2 to 10 days. The highest plant height was obtained from control. Leaf area decreased significantly despite the application of different powder, especially after 4 days of drought conditions. The highest root fresh and dry weight, raw ash were observed under control with the application of 7.5 g orange peel powder. Shoot dry weight decreased as the number of days exposed to drought increased, and the application of 15 g orange peel and cauliflower powder gave the highest results compared to control conditions. The highest dry matter was obtained from the application of 7.5 g and 15 cauliflower powder in the absence of drought. It has been revealed that as the duration of exposure to drought increases, the value decreases and plant powders are effective in increasing this value. Chlorophyll a, chlorophyll b and total chlorophyll values decreased significantly with drought, and the highest value was obtained from control conditions, followed by 15 cauliflower powder applications.

[a] ciiicicek@gmail.com https://orcid.org/0009-0004-9709-1603 | [b] iyavas@adu.edu.tr https://orcid.org/0000-0002-6863-9631

Introduction

One of the most important factors limiting plant growth and yield is water. It causes reductions of up to 60% in seed yield worldwide. With the changing climatic conditions, it is estimated that heat and drought stress will cause problems in production, especially in regions where high temperature and water are limited. Therefore, considering the increased input costs, drought resistance becomes even more important in the selection of common bean production in regions prone to drought stress (Hussaini et al. 2021; Singh et al., 2022).

Drought is one of the main abiotic stress factors that prevent the growth, development and yield of plants all over the world and it affects germination, vegetative and generative growth differently depending on the frequency and duration of the stress (Anjum et al., 2017). At the germination and seedling stage, it has a negative effect on plant growth by affecting morphological (seedling height and seedling biomass), physiological (water content), biochemical (amylase, protease and lipase activities) and molecular (stress proteins, aquaporins and dehydrins) properties (Yiğit et al., 2016; Hura et al., 2022). Drought in the vegetative period affects important plant processes such as photosynthesis, mineral nutrition, metabolism, translocation, phytohormone, transpiration (Fathi and Tari, 2016; Okunlola et al., 2017; Jyoti et al., 2017). In the generative period, it significantly reduces grain development, grain number, grain weight, yield and yield components and quality (Liu et al., 2018; Kuwayama et al., 2019). In the case of water deficiency in plant cells, morphological changes including limited growth and development, decreased photosynthesis efficiency and yield, and disorders in primary and secondary plant metabolism are observed (Grzesiak et al., 2002; Hura et al., 2016; Gupta et al., 2020; Wójcik. -Jagła et al., 2020). Plants prevent dehydration by performing an effective water uptake with a well-developed root system. They exposed to water stress synthesize and accumulate preservatives such as dehydrins or carbohydrates that stabilize the phospholipids of their cell membranes (Larcher, 2003). Drought, associated with abscisic acid (ABA) content, decreases transpiration rate, stomatal conductivity by stomatal closure and causes a sudden decrease in photosynthesis and CO_2 assimilation, significantly reducing growth and yield (Aghaee and Rahmani, 2020).

Fruit peel waste accumulates daily in significant amounts at domestic and industrial levels. They are important mineral nutrients such as calcium, iron, potassium, zinc, and are used as natural fertilizers, and also regulate the pH of the soil (Jariwala and Syed, 2016). Banana peel is a source of essential amino acids, fiber, polyunsaturated fatty acids and potassium (Qader, 2019). Citrus peels, like orange peel contain important components such as sugar and acids that affect soil acidity, photosynthesis and plant growth (Shed, 2005). Jariwala and Syed (2016) emphasized that fruit peels (sweet lime peel, orange peel, banana peel, pomegranate peel, citrate peel powder, alkaline peel powder) are effective in regulating the pH of the soil while citrate peel powder is used to reduce the phosphorus content of the soil. In addition, these fruit peels contain high amounts of nutrients such as N, P, K as a natural fertilizer (Jariwala and Syed, 2016). Apart from reducing pollution, banana peels contain nutrients such as potassium, calcium, magnesium, sulfur, phosphate and sodium for plants, increase soil fertility and the number of branches, and help plants to be resistant to diseases (Panwar, 2015; Qader, 2019). Cytokinins in fruit peels cause an increase in root length (Singh and Prasad, 2014). It was observed that the application of banana peels to the okra and the fruit peel to the *Solanum scabrum* positively affected the root length (Sakpere et al., 2018). It has been reported that fruit peel powder applications cause an increase in fenugreek plant height (Mercy et al., 2014), shoot height in *Solanum scabrum* (Kadir et al., 2016) and banana peel plant height in basil (Tan and So, 2018). Altaee (2019) emphasized that 10 g of banana peel powder applied to *Narcissus daffodil* L. significantly increased plant height, number of leaves, leaf length, chlorophyll content, number of flowers and length. In another study, it was stated that banana peel extract provided a maximum increase in chlorophyll a, chlorophyll b, total carotenoids and accordingly total pigments and photosynthetic pigments (Bakry et al., 2016). It was emphasized that foliar application also significantly increased the yield of quinoa. The application of fruit peel powder to the soil increased the leaf area in rye and the application of banana peel increased the leaf area in pea (Mercy et al., 2014; Wazir et al., 2018). Large amounts of peel are produced from oranges in a year. This waste product is a good source of molasses, pectin and limonene. It has been observed that orange peel powder significantly changes wheat dough properties and bread quality in terms of fiber, pectin and polyphenol content (Han et al., 2021). In another study, it was determined that banana and orange peels significantly increased plant height, number of branches, water content, number of pods, chlorophyll a, total chlorophyll content and carotenoids in chickpea (Qader, 2019). Banana peel extract applied at a dose of 500 mg/l increased the yield of quinoa due to its antioxidant properties (Sathya et al., 2014; Bakry et al., 2016). Fruit peel applications increased shoot and root growth rate, leaf pigments, relative water content and membrane stability index in *Schefflera arboricola* L. plant (El-Serafy et al., 2023).

Climate change and agriculture are interrelated processes and drought stress causes serious yield losses (Shafqat et al., 2021). Understanding the physiological and molecular basis of plants' adaptation to drought will provide new avenues for breeders to develop cultivars that are drought tolerant at key stages of growth and therefore better adapted to global climate changes. Another important issue is that fruit peel wastes accumulate in the environment in large amounts every day. This creates a serious problem and environmental pollution. Fruit peels are very rich in macro and micronutrients that are beneficial for plant growth. Therefore, using it as a fertilizer will reduce the amount of waste and the use of chemical fertilizers. Citrus peels are also rich in pectin and polysaccharides. The supportive effect of vegetable and fruit waste on plant growth is due to the presence of natural antioxidants such as vitamins, flavonoids, phenolic compounds necessary for plant growth.

Almost all of our soils are poor in organic matter. Due to the lack of organic matter, soil compaction occurs. It becomes tighter with the use of chemicals. Water permeability decreases. There is a drought problem in our lands, and due to compaction in the event of rainfall, water cannot penetrate deep into the soil. Therefore in this study, acidic orange peel, which is a natural source of antioxidants and an important waste, and cauliflower stems and leaves, which leave a large amount of residue in public markets, were used. It is thought that these wastes will improve the morphological and physiological characteristics of the bean plant by increasing soil moisture and plant water content under drought stress.

Materials and Methods

The research was carried out as a pot experiment in the application area of Aydin Adnan Menderes University, Kocarli Vocational School. The maximum average temperature value of the area where the research was carried out in 2021 is 25.7°C, and the average minimum temperature value is 10.9°C. The total annual precipitation is 482.8 mm. For many years (1970-2021), the average temperature value is 17.7°C, and the precipitation value is 644.7 mm in total. Seeds of Oturak Ayşe bean cultivar were used in this research. The experiment was arranged in a completely randomized design with three replicates

Material supply and processing peels and residues

Orange peels were obtained from the fruit juice factory in Sultanhisar, besides cauliflower leaves and stems were obtained from the public markets. Fruit peels and vegetable stems and leaves collected in February were cleaned and foreign materials were removed. Afterwards, fruit peels and vegetable stems and leaves were cut into small pieces of 1-5 cm and left to dry for 20-25 days. Then, dried fruit and vegetable wastes were pulverized with the help of a grinder. The ground samples were sieved separately using a 2 mm sieve and kept in tightly closed containers at room temperature (El-Bassiouny et al., 2016; Jariwala and Syed, 2016).

Material supplementation and sowing

The pot experiment was created by using 3 different doses (0, 7.5, 15 g/pot) of dried and ground powders obtained from 2 materials (orange peel and cauliflower leaves and stems)] wastes. Fruit peel and vegetable leaf-stem reside powders were filled into 108 pots (24 cm length and 21 cm deep), mixed with 7 kg of sandy-loamy soil sieved with 2 mm sieve. Five seeds were sowed in each pot and then reduced to three plants. Urea and super phosphate fertilizer was added to the pots at a rate of 10 $kg.da^{-1}$ before sowing (Muhummed, 2004). In the pots where drought will be applied, irrigation was stopped for 2, 4, 6, 8 and 10 days during the flowering period and irrigation was performed again after water stress application (Rahimi et al., 2010). To measure soil moisture percentage of pots, first dry pots were weighed and after irrigation, their moisture variation in terms of percent was measured during stress from 2 to 10 days. Plant height, leaf area, shoot and root fresh weight, shoot and root dry weight, dry matter, raw ash, chlorophyll a, chlorophyll b and total chlorophyll content were measured during the development period of the plant.

Measurement indicators

Dry matter

Ten gram (10 g) samples taken from the shoots after flowering were weighed with an accuracy of 0.01 g in a tared evaporation dish. It was left to dry for 3 hours in an oven set at 105 ºC beforehand, then cooled in a desiccator and weighed. It was heated for half an hour until the difference was 0.05, cooled in a desiccator and weighed (He et al., 2005).

Raw ash content

The sample determined after flowering was homogenized by grinding. 5-10 g of homogeneous sample was weighed into a pre-burned and tared porcelain crucible. It was burned in an oven at 550 ºC to constant weight and then cooled in a desiccator and the container was weighed.

Determination of chlorophyll content

After flowering the samples were washed in tap water dried, and then weighed on a sensitive balance. Then 0.5 g of $CaCO_3$ and 80% acetone were added, crushed in a mortar, the extraction obtained was washed with 80% acetone and filtered with the help of ordinary filter paper into 100 cc volumetric flask (Figure 1). The samples taken from here were centrifuged at 3000 rpm for 10 minutes and then the volume of the obtained extract was measured. The crude chlorophyll extract was then calculated as mg.total chlorophyll/L extract by substituting the absorption values at 645 and 663 nm wavelengths in the spectrophotometer in the formula below (Arnon, 1949).

Total chlorophyll (TC)=20.2 × A645 + 8.02 × A663

With this formula, the total amount of chlorophyll in one liter of the extract was found. The amount of chlorophyll per gram of product was obtained by dividing this value by the weight of the product used in the extraction. In the same way, chlorophyll a and chlorophyll b values were determined by using the following formulas (Arnon, 1949; A.O.A.C, 1975, Cevahir, 1991, Deveci and Şalk, 2000).

Chlorophyll a (Ca)=(0.0127×A663)–(0.0026×45.6×A645)
Chlorophyll b (Cb)=(0.0229×A663)–(0.00468×A645)

Statistical analysis

All the data were statistically analyzed with analysis of variance (ANOVA) procedures using the SPSS software (SPSS Inc 10). The experimental data about each study parameter were subjected to statistical analysis using the variance analysis technique, and their significance was tested by the "F" test (Steel and Torrie, 1980). When differences were found in ANOVA, means were compared using Fisher's protected least significant difference (LSD) test at P≤0.05.

Figure 1. Effect of different dried plant powders on chlorophyll content under drought stress conditions.

Results and Discussion

Table 1 includes data on common bean plant height. As the drought period increased, the plant heights of beans decreased. Orange peel application was more effective on plant height than cauliflower waste. Orange peel powder positively affected plant height in plants with 2 and 4 days of drought. Application of cauliflower waste (7.5 g) to plants until eight days of drought gave similar results to control conditions in terms of plant heights. Increasing the dose of cauliflower waste (15 g) was not effective in alleviating the effects of drought stress, and plant heights decreased. As the drought increased, the leaf area gradually decreased in common beans. After five days of drought stress, it was observed that the leaf water potential of *Plantago ovata* and *Plantago psyllium* decreased significantly, and the relative moisture content was more sensitive to drought stress, therefore it decreased in mild drought stress (Rahimi et al., 2010).

The highest leaf area values were obtained from the control conditions and from the application of 7.5 g of orange peel powder and plants without waste, respectively. The lowest data occurred in the application of cauliflower waste (7.5 and 15 g) under 10-day drought conditions. Low dose orange peel powder application was effective on leaf area under drought stress conditions (Table 2). Drought caused morphological changes in the common bean by reducing plant height and leaf area. Similar results has also been observed in studies conducted by Bañon et al. (2004) and Bhusal et al. (2020). Water increases the turgor pressure in the plant and plays an important role in the elongation of the plant. Drought has a negative effect on plant height (Al-Hayani et al., 2022).

Table 1 Effect of different dried plant powders on plant height (cm) under drought stress conditions.

Drought duration	Orange peel (g)			Cauliflower waste (g)		
	0	7.5	15	0	7.5	15
0	44.33a	44.67a	41.67a	41.00a	38.00a	41.00a
2	43.00ab	41.00b	41.00a	40.67a	37.33a	39.33b
4	43.00ab	41.00b	40.67a	38.33b	37.33a	37.67c
6	42.67bc	41.00b	39.00b	37.67b	37.00a	36.33cd
8	41.33c	38.33c	38.67bc	37.00bc	35.00b	35.33de
10	38.33d	39.33c	37.33c	39.00c	34.33b	34.00e

$LSD_{(AXBXC)}$: 1.446

Table 2. Effect of different dried plant powders on leaf area (cm^2) under drought stress conditions.

Drought duration	Orange peel (g)			Cauliflower waste (g)		
	0	7.5	15	0	7.5	15
0	42.133a	44.053a	39.110a	39.110a	23.040a	26.887a
2	41.707b	41.880b	25.897b	25.897b	21.850b	25.880b
4	40.827c	27.947c	22.880c	22.880c	21.960b	20.053c
6	29.060c	27.827c	21.050d	21.050d	20.827c	19.853c
8	27.037d	24.887d	21.047d	21.047d	21.040c	18.980d
10	21.067e	21.493e	20.040e	20.040e	18.103d	17.950e

$LSD_{(AXBXC)}$: 0.394

Table 3. Effect of different dried plant powders on root fresh weight (g) under drought stress conditions.

Drought duration	Orange peel (g)			Cauliflower waste (g)		
	0	7.5	15	0	7.5	15
0	3.712a	4.195a	3.285a	3.208a	1.983a	3.243a
2	3.658ab	3.300b	3.050b	2.998b	1.942a	2.500b
4	3.602b	3.276b	2.800c	1.965c	1.766b	1.994c
6	3.449c	3.240b	2.100d	1.875d	0.700c	0.642d
8	3.286d	2.144c	1.998e	1.800d	0.688c	0.200e
10	2.108e	2.107c	1.980e	0.796e	0.685c	0.150e

$LSD_{(AXBXC)}$: 0.079

Table 4. Effect of different dried plant powders on root dry weight (g) under drought stress conditions.

Drought duration	Orange peel (g)			Cauliflower waste (g)		
	0	7.5	15	0	7.5	15
0	0.149a	0.151a	0.148a	0.258a	0.082a	0.250a
2	0.140a	0.131a	0.109a	0.113b	0.079a	0.107b
4	0.139a	0.113a	0.108a	0.110b	0.076a	0.080b
6	0.139a	0.110a	0.096a	0.093b	0.062a	0.068b
8	0.118a	0.092a	0.086a	0.079b	0.060a	0.050b
10	0.093a	0.073a	0.080a	0.070b	0.060a	0.048b

$LSD_{(AXBXC)}$: 0.142

A significant decrease in plant height was observed in *Vigna unguiculata* (Abdel Aziz, 2008; Khater et al., 2018) and *Vigna radiata* L. (Bangar et al., 2019) exposed to drought. Dry conditions at the beginning of flowering and pod formation in *Arachis hypogaea* led to a significant decrease in plant height (Muhanna and Saqr, 2016). In other study, drought conditions in the vegetative period caused a decrease in internode length, number of nodes, plant height, first pod height, leaf area, shoot dry weight and root length (Stanak et al., 2023). Similar results were observed in the cotton (Ödemiş and Candemir, 2023). It was determined that low-dose ground plant wastes applied to the common bean together with drought stress for up to eight days were more effective than high-dose, also orange peel waste application. Application of fruit wastes to soil against heat stress increased the growth of *Schefflera arboricola* and the highest value was obtained in orange peel waste compared to banana and pomegranate wastes (El-Serafy et al., 2023).

Root fresh weight decreased significantly with drought conditions. Application of low dose of orange peel powder (7.5 g) alleviated the effects of drought for up to 8 days. It was revealed that the dose increase (15 g) was more effective on only 2-day short-term drought (Table 3). Cauliflower waste application (7.5 g) gave similar results in drought stress lasting longer than 6 days in common beans and was significantly affected by stress. With the increase in drought stress, cauliflower waste applied at high doses could not prevent the decrease in root fresh weight (Table 3). The highest root dry weight of common beans was obtained under control conditions, while the lowest weight was observed after 10 days of drought. Orange peel powder and cauliflower wastes were not effective in increasing root dry weight of beans against drought conditions and root dry weight decreased (Table 4).

The highest shoot fresh weight was obtained under control conditions and decreased significantly with drought. In drought conditions, low dose of orange peel powder (7.5 g) applied did not make a significant difference in shoot fresh weight values compared to the control. The effect of low-dose application of drought on shoot fresh weight was significant and positive. When the application of orange peel powder was increased (15 g), the applications made during 2 and 4 days of drought gave similar results. After eight days of drought, a significant decrease was observed. Application of cauliflower waste in drought conditions gave lower averages than orange peel powder. While low dose cauliflower waste was effective for up to eight days, it showed a high decrease with the increase of drought (Table 5). When Table 6 is examined, it was observed that the shoot dry weight value decreased gradually with drought stress. After 10 days of drought, shoot dry weight of common beans decreased significantly and orange peel powder could not prevent the decrease. Low cauliflower waste (7.5 g) application was more effective than high dose (15 g) in drought conditions. The lowest value was obtained from the application of 15 g cauliflower waste under drought stress conditions for 10 days. Root and shoot fresh weight decreased significantly with arid conditions, 7.5 g of orange peel and cauliflower waste application alleviated the effects of drought in common bean under drought stress up to eight days. Root and shoot dry weight decreased significantly in drought, orange peel and cauliflower wastes could not alleviate the negative effect. The application of oak leaf powder to the tomato in drought conditions affected the root fresh and dry weight positively (Tahir et al., 2022). Application of *Bacillus velezensis* and orange peel to 20 soybean genotypes significantly increased plant height (14.3%), leaf area (11.4%), total above-ground dry weight (13.2%) and root dry weight (12.5%) (Pacheco da Silva et al., 2022). In another study conducted with peanuts, it was observed that the application of orange peel powder against drought stress provided the highest plant dry weight (Bagwell, 2020).

Dry matter value in plant showed a significant decrease in drought conditions. Higher dry matter values were obtained in the application of orange peel powder than in the low-dose application, except for the 10-day drought stress. The highest value after the application of cauliflower waste under stress conditions was obtained in two days of drought stress (Table 7). Dry matter accumulation in common bean decreased in arid conditions. This is due to the destruction of chlorophyll in the plant under stress. The fact that the leaf area is directly related to the photosynthesis activity also affects the amount of dry matter, yield and quality (Ödemiş and Candemir, 2023).

Table 5. Effect of different dried plant powders on shoot fresh weight (g) under drought stress conditions.

Drought duration	Orange peel (g)			Cauliflower waste (g)		
	0	7.5	15	0	7.5	15
0	3.877a	3.093a	3.793a	2.980a	2.560a	3.063a
2	3.810a	3.050a	2.890b	2.663b	1.930b	2.731b
4	3.517b	2.997a	2.710b	2.060c	1.870b	1.820c
6	3.103c	2.973a	1.967c	1.913c	1.740b	1.001d
8	3.160c	2.957a	1.960c	1.158d	0.977c	0.890d
10	2.767d	2.950a	1.957c	1.122d	0.877c	0.783d

LSD $_{(AXBXC):}$ 0.142

Table 6 Effect of different dried plant powders on shoot dry weight (g) under drought stress conditions.

Drought duration	Orange peel (g)			Cauliflower waste (g)		
	0	7.5	15	0	7.5	15
0	0.313a	0.240a	0.284a	0.205a	0.050a	0.159a
2	0.297b	0.232b	0.196b	0.156b	0.042b	0.150b
4	0.272c	0.208c	0.158c	0.050c	0.046ab	0.044c
6	0.250d	0.200d	0.153cd	0.049c	0.046ab	0.044c
8	0.226e	0.155e	0.150d	0.043cd	0.040b	0.030d
10	0.042f	0.042f	0.050e	0.038d	0.040b	0.026d

LSD $_{(AXBXC):}$ 0.008

Table 7. Effect of different dried plant powders on dry matter (g) under drought stress conditions.

Drought duration	Orange peel (g)			Cauliflower waste (g)		
	0	7.5	15	0	7.5	15
0	13.040a	11.880a	13.520a	13.650a	16.410a	14.360a
2	12.791b	11.770b	12.560b	12.160b	13.370b	12.700b
4	12.600c	11.690c	12.330c	11.800c	12.180c	12.220c
6	11.780d	11.601d	11.910d	11.727d	12.210c	12.130d
8	11.600e	11.410e	11.471e	11.600e	11.950d	11.580e
10	10.880f	11.190f	10.570f	11.450f	11.381e	11.480f

LSD $_{(AXBXC):}$ 0.064

Table 8. Effect of different dried plant powders on raw ash value (%) under drought stress conditions.

Drought duration	Orange peel (g)			Cauliflower waste (g)		
	0	7.5	15	0	7.5	15
0	2.380a	3.260a	2.060a	2.470a	4.020a	3.900a
2	2.281b	2.111b	1.987ab	2.280b	2.720b	2.371b
4	2.131c	2.081b	1.961b	2.071c	2.371c	2.100c
6	1.580d	1.340c	1.351c	1.834d	2.021d	1.790d
8	0.500e	0.920d	1.090d	1.530e	1.810e	1.260e
10	0.000f	0.790e	0.720e	1.440f	0.850f	0.880f

LSD $_{(AXBXC)}$: 0.074

Table 9. Effect of different dried plant powders on chlorophyll a content under drought stress conditions.

Drought duration	Orange peel (g)			Cauliflower waste (g)		
	0	7.5	15	0	7.5	15
0	1.110a	0.610a	0.571a	0.690a	0.620a	1.060a
2	0.490b	0.533b	0.510b	0.650b	0.450b	0.590b
4	0.470c	0.490c	0.500c	0.470c	0.410c	0.530c
6	0.350d	0.420d	0.460d	0.450d	0.350d	0.420d
8	0.320e	0.410e	0.330e	0.350e	0.320e	0.380e
10	0.270f	0.280f	0.310f	0.230f	0.201f	0.220f

LSD $_{(AXBXC)}$: 0.001

Table 10. Effect of different dried plant powders on chlorophyll b content under drought stress conditions.

Drought duration	Orange peel (g)			Cauliflower waste (g)		
	0	7.5	15	0	7.5	15
0	0.530a	0.340a	0.290a	0.450a	0.350a	0.520a
2	0.240b	0.260b	0.260b	0.400b	0.220b	0.490b
4	0.220c	0.260b	0.250c	0.240c	0.190c	0.320c
6	0.160d	0.200c	0.220d	0.220d	0.170d	0.270d
8	0.150e	0.190d	0.160e	0.170e	0.150e	0.200e
10	0.130f	0.130e	0.150f	0.110f	0.080f	0.100f

LSD $_{(AXBXC)}$: 0.001

Table 11. Effect of different dried plant powders on total chlorophyll content under drought stress conditions.

Drought duration	Orange peel (g)			Cauliflower waste (g)		
	0	7.5	15	0	7.5	15
0	1.640a	0.950a	0.860a	1.140a	0.970a	1.580a
2	0.731b	0.790b	0.760b	1.050b	0.670b	1.020b
4	0.690c	0.750c	0.760b	0.710c	0.600c	0.910c
6	0.500d	0.620d	0.680c	0.600d	0.520d	0.620d
8	0.470e	0.600e	0.480d	0.520e	0.470e	0.560e
10	0.400f	0.410f	0.470e	0.340f	0.280f	0.320f

LSD $_{(AXBXC)}$: 0.001

Raw ash value decreased with increasing drought stress. In the highest drought application (10 days), this value could not be calculated due to insufficient vegetation and it is shown as zero in the table. It was observed that orange peel powder application was more effective than cauliflower waste in two and four-day drought applications (Table 8). Raw ash content in common bean decreased significantly with drought conditions and it was observed that orange peel powder was more effective than cauliflower waste in short-term drought applications (2-4 days). The highest raw ash content in chickpea was obtained with two irrigations (3.56%) during the 50% flower + 50% pod filling period, while the lowest value was obtained after a single irrigation (1.66%) before flowering (Kırnak et al., 2017). With the decrease in irrigation, the raw ash value decreased. In another study, it was observed that when the vetch was exposed to salt stress the raw ash content increased with the increase in stress (Parlak and Parlak, 2005; Al-Ghumaiz, 2013).

Chlorophyll a content decreased gradually in drought conditions. The decreases were less at low drought degrees and the application of low-dose cauliflower waste (7.5 g) appeared to be more effective (Table 9). After ten days of continuous drought applications, it was observed that the chlorophyll b content decreased significantly. Application of orange peel powder to common bean (7.5 g) in drought stress up to eight days gave similar results and it was determined that the decrease in chlorophyll b was lower than other stress conditions. (Table 10). Total chlorophyll decreased significantly under drought conditions, the highest value was obtained under control conditions. Orange peel powder and cauliflower waste could not prevent the decrease in total chlorophyll value as the drought period increased. The increase in the cauliflower waste dose led to an increase in the total chlorophyll value compared to the low application dose (Table 11). Chlorophyll a, chlorophyll b and total chlorophyll content decreased gradually in drought conditions.

Chlorophyll a was more effective on drought with the application of 7.5 g cauliflower waste. In drought stress up to eight days, application of 7.5 g of orange peel powder to common bean alleviated the effects of drought on chlorophyll b value. The application of orange peel and cauliflower waste powder was ineffective on the total chlorophyll with the increase of drought duration. Cauliflower waste was more effective in high dose. After the application of *Moringa olifera* leaf extract from the leaves to the soybean against arid conditions, shoot and root length, shoot fresh and dry weight, chlorophyll a, chlorophyll b and total pigments increased (Hanafy, 2017). Similar results were also observed in the wheat (Azra et al., 2013). The effect of orange peels on the photosynthetic pigments of the quinoa in drought conditions was positive. Chlorophyll a, chlorophyll b, carotenoid and total pigment content increased significantly after the application in quinoa (El-Bassiouny et al., 2016). In another study conducted with quinoa in drought, it was observed that foliar application of banana peel extract (500 mg/l) significantly increased the fresh and dry weight of the plant and the shoot length increased by 47%. Foliar application of 500 mg/l banana peel also caused an increase in chlorophyll a (61%), chlorophyll b (47%), carotenoid (163%) and total pigment content (55%) (Bakry et al., 2016). Fruit peel waste significantly improved the leaf pigment content, the highest value was obtained from orange peel waste (El -Serafy et al., 2023). In soil pollution the first organelle affected in plants is the root. Potato peel application under stress conditions caused a significant increase in root length, leaf area, chlorophyll a, chlorophyll b, carotenoid and total chlorophyll content of *Vigna mungo* (Askari et al., 2017). Potato peels attract copper and prevent salt from entering the plant due to the high carbohydrate and phenolic compounds it contains (Azadeh et al., 2012).

Conclusion

The potential of orange peel and cauliflower waste to stimulate drought tolerance on common bean was investigated. These wastes applied to the soil allowed growing common beans that are more resistant to drought stress. Fruit peel and cauliflower waste powder improved plant height, leaf area, shoot and root growth, dry matter, raw ash and promoted chlorophyll content in leaves. Against drought stress lasting up to eight days, 7.5 g/pot orange peel application showed better performance compared to cauliflower waste. The use of orange peels on common beans grown in drought conditions during the flowering period not only improved growth and plant tolerance, but also reduced the amount of waste discharged into the environment.

Acknowledgements: We thank the 2209/A University Students Research Projects Support Program 2nd semester for funding (Project number: 1919B012218651). We would also like to thank Burcu Keser and Ilker Ozdemir for their assistance throughout the study.

Author contributions Conceptualization, IY; Methodology, IY; Morphological analyzes, IY; Physiological analyzes, IY, ESC; Project administration, IY; wrote the manuscript IY.

Funding This work was supported by the 2209/A University Students Research Projects [Project number: 1919B012218651].

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Data Availability

The data analysed in this study have been included in the article and its supplementary information.

References

Abdel Aziz M. 2008. The effect of supplemental irrigation on the growth of ordinary beans and some components of the crop Tishreen University. Journal for Research and Scientific Studies, 3(30): 9-21.

Aghaee P, Rahmani F. 2020. Seed Priming with 24-Epibrassinolide Alters Growth and Phenylpropanoid Pathway in Flax in Response to Water Deficit. Journal of Agricultural Science and Technology, 22(4): 1039-1052.

Al-Ghumaiz NS. 2013. Response of five introduced forage grass cultivars to salinity stress under Irrigation. Grassland Science in Europe, 18: 282-284.

Al-Hayani EH, Attarbashi RW, Al-Kazzaz AGM. 2022. The Effect of Drought Stress in Some Vegetative Growth and the Physiological Characteristics and the Quality and Quantity Characteristics Yield of Some Leguminosae Family. Plants, 13(1):561-574

Altaee AH. 2019. Effect of plants extract in vegetative and flowering growth, aromatic and volatile oil extracted *from Narcissus daffodil* L plant. In IOP Conference Series: Earth and Environmental Science, 388(1): 012074. IOP Publishing. DOI. 10.1088/1755-1315/388/1/012074

Anjum SA, Ashraf U, Zohaib A, Tanveer M, Naeem M, Ali I, Tabassum T, Nazir U. 2017. Growth and development responses of crop plants under drought stress: a review. Zemdirbyste, 104: 267-276. DOI. 10.13080/z-a.2017.104.034

AOAC. 1975. Official Methods of the Association of Official Analytical Chimits Vol II. (Eds. Horwitz. W. Senzcel. A.. Reynolds. H.. L. Douglas). Washington. p50.

Arnon DI. 1949. Copper Enzymes in Isolated Chloroplast. Polyphnenolixidase in *Beta vulgaris*. Plant Physil, 24: 1-5.

Askari S, Siddiqui A, Kaleem M. 2017. Potato peel mediated improvement in organic substances of *Vigna mungo* growing under copper stress. Journal of Pharmacognosy and Phytochemistry, 6(4): 1373-1378.

Azadeh MS, Hashemi P, Nima H, Amirhosein E. 2012. Phenolics in Potato Peels: Extraction and Utilization asNatural Antioxidants. World Appli Sci J, 18:191-195.

Azra Y, Basra SMA, Wahid A, Farooq M, Nouman W, Rehman HU, Hussain N. 2013. Improving drought resistance in wheat (*Triticum aestivum*) by exogenous application of growth enhancers. International Journal of Agriculture and Biology, 15: 1307-1312.

Bagwell JW. 2020. Improving Drought Stress Tolerance of Peanut Using PGPR and Orange Peel Amendment (Doctoral dissertation, Auburn University). Auburn, Alabama.

Bakry AB, Ibrahim FM, Abdallah MMS, Bassiouny HMS. 2016. Effect of banana peel extract or tryptophan on growth, yield and some biochemical aspects of quinoa plants underwater deficit. International Journal of Pharm Tech Research, 9(8): 276-287.

Bangar P, Chaudhury A, Tiwari B, Kumar S, Kumari R, Bhat K. 2019. Morphophysiological and biochemical response of mugbean [*Vigna radiata* (L.)] varieties at different developmental stages under drought stress. Turk J Biol, 43(1): 58-69. DOI.10.3906/biy-1801-64

Bañon SJ, Fernandez A, Franco JA, Torrecillas A, Alarcón JJ Sánchez-Blanco MJ. 2004. Effects of water stress and night temperature preconditioning on water relations and morphological and anatomical changes of lotus creticus plants. Scientia Horticulturae, 101(3): 333- 342. https://doi.org/10.1016/j.scienta.2003.11.007

Bhusal N, Lee M, Han AR, Han A, Kim HS. 2020. Responses to drought stress in *Prunus sargentii* and *Larix kaempferi* seedlings using morphological and physiological parameters. For Ecol Manag, 465: 118099. https://doi.org/ 10.1016/j.foreco.2020.118099

Cevahir G. 1991. *Helianthus annuus* Bitkisinde Tuz Stresi ve Senesens Arasındaki İlişki. İstanbul Üniv. Biyoloji Fak. (Yüksek Lisans Tezi). İstanbul.

Danish S, Tahir FA, Rasheed MK, Ahmad N, Ali MA, Kiran S, ... & Butt B. 2019. Effect of foliar application of Fe and banana peel waste biochar on growth, chlorophyll content and accessory pigments synthesis in spinach under chromium (IV) toxicity. Open Agriculture, 4(1): 381-390. https://doi.org/10.1515/opag-2019-0034

Deveci M, Şalk A. 1995. Tekirdağ Şartlarında Ispanak Yetiştiriciliğinde Farklı Ekim Zamanı ve Bitki Sıklığının Gelişme ve Verim Üzerine Etkisi. Tekirdağ Ziraat Fak Dergisi, 4(1-2): 1-11.

El-Awadi ME, Sadak MS, Dawood MG. 2021. Comparative effect of potassium and banana peel in alleviating the deleterious effect of water deficit on soybean plants. J Mater Environ Sci, 12: 929-943.

El- Basiouny HMS, Abdullah MM, Bakry AB. 2016. Effect of Orange Peel Extract or Ascorbic Acid on Growth, yield and Some Biochemical Aspects of Quinoa Plants under Water Deficit. Internation journal of farm tech and research, 9(9): 86-96

El-Serafy RS, El-Sheshtawy ANA, Dahab AA. 2023. Fruit Peel Soil Supplementation Induces Physiological and Biochemical Tolerance in *Schefflera arboricola* L. Grown Under Heat Conditions. Journal of Soil Science and Plant Nutrition, 23(1): 1046-1059. https://doi.org/10.1007/s42729-022-01102-5

Fathi A, Tari DB. 2016. Effect of drought stress and its mechanism in plants. Int. J. Life Sci, 10: 1-6. DOI. 10.3126/ijls.v10i1.14509

Grzesiak S, Grzesiak M, Filek W, Hura T, Stabryła J. 2002. The impact of different soil moisture and soil compaction on the growth of triticale root system. Acta Physiol Plant, 24: 331-342. https://doi.org/10.1007/s11738-002-0059-8

Gupta A, Rico-Medina A, Caño-Delgado AI. 2020. The physiology of plant responses to drought. Science, 368: 266-269. https://doi.org/10.1126/science.aaz7614

Han L, Zhang J, Cao X. 2021. Effects of orange peel powder on rheological properties of wheat dough and bread aging. Food Science and Nutrition, 9(2): 1061-1069. https://doi.org/10.1002/fsn3.2080

Hanafy R. 2017. Using Moringa olifera leaf extract as a bio-fertilizer for drought stress mitigation of *Glycine max* L. plants. Egyptian Journal of Botany, 57(2): 281-292. DOI: 10.21608/ejbo.2017.596.1027

He Y, Liu Y, Cao W, Huai M, Xu B, Huang B. 2005. Effects of salicylic acid on heat tolerance associated with antioxidant metabolism in Kentucky bluegrass. Crop science, 45(3): 988-995. https://doi.org/10.2135/cropsci2003.0678

Hura T, Dziurka M, Hura K, Ostrowska A, Dziurka K. 2016. Different allocation of carbohydrates and phenolics in dehydrated leaves of triticale. J Plant Physiol, 202: 1-9. https://doi.org/10.1016/j.jplph.2016.06.018

Hura T, Hura K, Ostrowska A. 2022. Drought-Stress Induced Physiological and Molecular Changes in Plants. International Journal of Molecular Sciences, 23(9): 4698. https://doi.org/10.3390/ijms23094698

Hussaini SMB, Sidle RC, Kazimi Z, Khan AA, Rezaei AQ, Ghulami Z ... & Muhmmadi Z. 2021. Drought tolerant varieties of common beans (*Phaseolus vulgaris*) in central Afghanistan. Agronomy, 11(11): 2181. https://doi.org/10.3390/agronomy11112181

Jariwala HJ, Syed HS. 2016. Study on use of fruit peels powder as a fertilizer. National Conference on Recent Advances in Environmental Science and Engineering Technologies, 1-3.

Jyoti C, Kakralya BL, Singhal RK. 2017. Evaluation of morpho-physiological attributes of fenugreek (*Trigonella foenum graecum*) genotypes under different waterregimes. Int J Plant Sci, 12: 271-281. DOI. 10.15740/HAS/IJPS/12.2/271-281

Kadir AA, Rahman NA, Azhari NW. 2016. The utilization of banana peel in the fermentation liquid in food waste composting. IOP Conference Series: Materials Science and Engineering, 136: 1-8. https://doi.org/10.1088/1757-899x/136/1/012055

Khater MA, Dawood MG, Sadak MS, Shalaby MAF. 2018. Enhancement the performance of cowpea plants grown under drought conditions via trehalose application. Middle East J Agric Res 7(3): 782-800.

Kırnak H, Varol İS, İrik HA, Özaktan H. 2017. Nohut Bitkisinde Farklı Gelişim Dönemlerinde Uygulanan Ek Sulamanın Ham Protein, Ham Yağ ve Ham Kül İçeriğine Etkisi. Gaziosmanpaşa Bilimsel Araştırma Dergisi, 6: 168-176.

Kuwayama Y, Thompson A, Bernknopf R, Zaitchik B, Vail P. 2019. Estimating the impact of drought on agriculture using the US drought monitor. Am J Agric Econ, 101: 193-210. https://doi.org/10.1093/ajae/aay037

Larcher W. 2003. Physiological Plant Ecology: Ecophysiology and Stress Physiology of Functional Groups, 4th ed.; Springer: Berlin/Heidelberg, Germany.

Liu X, Pan Y, Zhu X, Yang T, Bai J, Sun Z. 2018. Drought evolution and its impact on the crop yield in the North China plain. J Hydrol, 564: 984-996.

Mercy S, Mubsira BS, Jenifer I. 2014. Application of different fruit peels formulations as a natural fertilizer for plant growth. International Journal of Scientific & Technology Research, 3(1): 300-307.

Muhammed MQ. 2004. Effect of zinc and its interaction with two auxins (IAA & NAA) on the growth and development of Pea (*Pisum sativum* L.) Var. Little Marvel. Thesis, Erbil. Iraq

Muhanna A Saqr S. 2016. The effect of drought stress on the growth and yield of groundnuts in Tartous Governorate. Al-Baath University Journal, 38(22):33-50.

Okunlola GO, Olatunji OA, Akinwale RO, Tariq A, Adelusi AA. 2017. Physiological response of the three most cultivated pepper species (*Capsicum* spp.) in Africa to drought stress imposed at three stages of growth and development. Sci Hortic, 224: 198-205.

Ödemiş B, Candemir DK. 2023. The Effects of Water Stress on Cotton Leaf Area and Leaf Morphology. Kahramanmaraş Sütçü İmam Üniversitesi Tarım ve Doğa Dergisi, 26(1): 140-149.

Pacheco da Silva ML, Moen FS, Liles MR. 2022. The Response to Inoculation with PGPR Plus Orange Peel Amendment on Soybean Is Cultivar and Environment Dependent. Plants, 11: 1138.

Panwar N. 2015. Studies on Physicochemical Characteristics and Fertility of Soil by Addition of Banana Peels –Waste Management. International Journal for Scientific Research & Development, 3(1): 121-125

Parlak M, Parlak AÖ. 2005. Sulama Suyu Tuzluluk Düzeylerinin Silajlık Sorgumun (*Sorghum bicolor* (L.) Moench) Verimine ve Toprak Tuzluluğuna Etkisi, Ankara Üniversitesi Ziraat Fakültesi Tarım Bilimleri Dergisi, 12(1): 8-13.

Qader HR. 2019. Influence combination of fruits peel and fertilizer methods on growth and yield of chickpea (*Cicer areitinum*) L. Plants. ZANCO Journal of Pure and Applied Sciences, 31(3): 45-51

Rahimi A, Hosseini SM, Pooryoosef M, Fateh I. 2010. Variation of leaf water potential, relative water content and SPAD under gradual drought stress and stress recovery in two medicinal species of *Plantago ovata* and *P. psyllium*. Plant Ecophysiol, 2: 53-60

Sakpere AMA, Bankole M, Oyekola OB, Akinyemi OS, Akosile OR, Adegboye OA, ... & Obisesan IA. 2018. Effect of different Moringa oleifera extracts and fruit peels on the growth of Solanum scabrum. International Journal of Biological and Chemical Sciences, 12(4): 1543-1549.

Sathya M. 2014. Assaying the antioxidant activity of banana peel. American J of Biochem. And Molecular Biology, 4(3): 122-129

Shafqat W, Mazrou YS, Nehela Y, Ikram S, Bibi S, Naqvi SA, ... & Jaskani MJ. 2021. Effect of three water regimes on the physiological and anatomical structure of stem and leaves of different citrus rootstocks with distinct degrees of tolerance to drought stress. Horticulturae, 7(12): 554. https://doi.org/10.3390/horticulturae7120554

Shed K. 2005. Effects of Citrus Fruits as Fertilizers Using Photosynthetic Testing, Growth Rate and Leaf Area Ratio of *Hedera helix*. *LBS145* Cell and Molecular Biology, Section 1 M2.

Singh S, Prasad SM. 2014 Growth, photosynthesis and oxidative responses of *Solanum melongena* L. seedlings to cadmium stress: Mechanism of toxicity amelioration by kinetin. Scientia Horticulturae, 176: 1-10. https://doi.org/10.1016/j.scienta.2014.06.022

Singh A, Lehner I, Schöb C. 2022. Effect of drought on bean yield is mediated by intraspecific variation in crop mixtures. Frontiers in plant science, 13: 813417. https://doi.org/10.3389/fpls.2022.813417

SPSS for Windows: Base 10.0 Applications Guide. Chicago, Illinois.

Staniak M, Szpunar-Krok E, Kocira A. 2023. Responses of soybean to selected abiotic stresses—Photoperiod, temperature and water. Agriculture, 13(1): 146. https://doi.org/10.3390/agriculture13010146

Steel RGD, Torrie JH. 1980. Principles and procedures of statistics. A biometrical approach, 2nd Edition, McGraw-Hill Book Company, New York.

Tahir NAR, Rasul KS, Lateef DD, Grundler FM. 2022. Effects of oak leaf extract, biofertilizer, and soil containing oak leaf powder on tomato growth and biochemical characteristics under water stress conditions. Agriculture, 12(12): 2082. https://doi.org/10.3390/agriculture12122082

Tan N, So RC. 2018. Biochar from waste banana peels as growth promoter for holy basil (*Ocimum tenuiflorum*) and chili pepper (*Capsicum annum*). Materials for Energy, Efficiency and Sustainability TechConnect Briefs, 239-241. https://briefs.techconnect.org/wp-content/volumes/TCB2018v2/pdf/697.pdf

Wazir A, Gul Z, Hussain M. 2018. Comparative study of various organic fertilizers effect on growth and yield of two economically important crops, potato and pea. Agricultural Sciences, 9(06): 703

Wójcik-Jagła M, Rapacz M, Dubas E, Krzewska M, Kopec´ P, Nowicka A, Ostrowska A, Malaga S, Zur I. 2020. Candidate Genes for Freezing and Drought Tolerance Selected on the Basis of Proteome Analysis in Doubled Haploid Lines of Barley. Int J Mol Sci, 21 (6): 2062. https://doi.org/10.3390/ijms21062062

Yigit N, Sevik H, Cetin M, Kaya N. 2016. Determination of the effect of drought stress on the seed germination in some plant species. Water Stress Plants, 4362.