Journal of Materials and Environmental Science
ISSN : 2028-2508
CODEN : JMESCN

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J. Mater. Environ. Sci., 2021, Volume 12, Issue 7, Page 929-943

http://www.jmaterenvironsci.com

# Comparative effect of potassium and banana peel in alleviating the deleterious effect of water deficit on soybean plants

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*Received 15 April 2021,*
*Revised 09 July 2021,*
*Accepted 11 July 2021*

*Keywords*
- ✓ *Glycine max,*
- ✓ *Organic fertilizer,*
- ✓ *Inorganic fertilizer,*
- ✓ *Banana peel*

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## Abstract

A trial was performed at wire house of National Research Centre, Egypt during two summer seasons 2016 and 2017 to compare effect of potassium and banana peel in alleviating the deleterious effect of water deficit on soybean plants. Potassium treatments as K1 (1.35 g/pot); K2 (2.70 g/pot) and banana peel treatments as B1 (5 g/pot); B2 (10 g/pot) were added to soil before sowing. These treatments were divided into two categories. The first category undergoes irrigation twice/week (Well-Watered WW). The second category undergoes water deficit since it irrigates once/week (water Deficit; WD) at 15 days old seedlings and till the end of the trial. Results show that water deficit decreased growth parameters, total photosynthetic pigments, seed yield and yield components as well as some biochemical composition of the yielded seeds as carbohydrate, oil, tannins and antioxidant activity accompanied by increases in total phenolic content and flavonoid in the yielded seeds. On the other hand, all applied treatments either potassium or banana peel caused significant increases in most parameters under investigation as growth parameters, all components of photosynthetic pigments, seed yield and yield components as well as some biochemical composition of the yielded seeds. Banana peel treatments were more effective in reducing deleterious effect of water deficit than potassium treatments. It is obvious that banana peel treatment at 10 g/pot was the most pronounced treatment either under well-watered conditions or under water deficit conditions.

## 1. Introduction

Soybean (Glycine *max* (L.) Merrill) is grown in almost all parts of the world for human consumption, industry and animal feed [1]. In Egypt, soybean growth period ranges usually between 100 and 120 days and requires 325-436 mm of irrigation water depending on the location [2]. The most important phenological growth stages of soybean, which need adequate water, are during pod development and seed fill [3]. These are the stages when water stress can lead to a significant decrease in yield. Soybean is considered as one of the most important oil crops due to high protein percentage close to the value of animal protein. Soybean seeds contain about 20% oil, 35% carbohydrate content and 35-40% protein.

Water deficit is one of the major limiting factors for crop productivity worldwide, particularly in warm, arid and semiarid parts of the world [4,5]. The decreases in crop yields associated with abiotic stress factors including drought, ranged between54% and 82% as reported by Waraich et al. [6]. The risk of water deficit will be increased in the next decades. Hence, for sustaining food security, the development of shot-gun, inexpensive and effective approaches are essential to ensure high yield of crops in drought-prone areas of the world by minimizing the detrimental effects of drought. The severity of water stress not only depends on the duration and intensity [7] but also on the growth stage when plants are affected, i.e., seedling, vegetative, or reproductive stage [8,9,10], all of which have deferential responses but ultimately all lead to yield loss. At the early stage of plant growth, water stress reduced growth, development, and $CO_2$ fixation, while water stress at the reproductive stage leads to reproductive failure, less allocation of assimilates to the grains, and reduced grain filling period [9,10]. Plants possess different mechanisms to escape, avoid and/or resist to drought by adjusting their physiological and biochemical processes according to the availability of water in their habitat [11]. Water deficit induced a significant decrease in evapo-transpiration through stomatal closure [12], modified leaf hydraulic architecture, decreased assimilation of carbon and confined effective phloem transport of nutrients [13]; decreased the metabolic factors such as decrease in chlorophyll content and enhanced accumulation of proline [14,15]. Water deficit -induced alterations in biochemical processes, it caused oxidative stress due to synthesis of reactive oxygen species (ROS) that caused damage to lipids, nucleic acids, proteins and chlorophyll pigments; thereby, leading to membrane leakage, inhibited photosynthetic electron transport chain and $CO_2$ fixation [16,17,18].

Potassium is not only an essential macronutrient for plant growth and development [19,20] but also a primary osmoticum in the maintenance of the low water potential of plant tissues. Therefore, accumulation of potassium in plant tissues under drought stress may play an important role in water uptake along a soil-plant gradient [21]. Potassium application under drought stress moderates the adverse effects of water shortage on plant growth [22,23]. Potassium is known as a stress alleviator plant nutrient which alleviates the negative consequences of abiotic stresses by regulating the physiological and biochemical process in plants [6,24,25]. Its adequate supply during growth period improves the water relations of plant and photosynthesis [26], maintains turgor pressure of cell which is necessary for cell expansion, helps in osmotic-regulation of plant cell, assists in opening and closing of stomata [27], activates more than 60 enzymes [28] and synthesizes the protein [29], stimulates the translocation of photosynthates, controls of ionic balance, regulates of water use, [30] and enhances the crop yield [31,32]. Dawood et al. [33] concluded that potassium application (150 mg $K_2O$ /Kg soil) mitigated the adverse effect of salinity through the effect of potassium in enhancing the level of photosynthetic pigments; antioxidant enzyme activity, osmoprotectant levels; all of which were reflected in an improvement in common bean performance. A reduction in photosynthetic rate, respiration rate, total chlorophyll content, starch content and total soluble carbohydrates is observed under water stress meanwhile application of potassium improved the overall grain yield of crop pant [34]. Waraich et al. [6] reported that potassium nutrition keeps a balance between antioxidant enzymes and reactive oxygen species and regulates osmotic and turgor pressure in order to avoid yield losses from drought. The application of K enhances the activities of different antioxidant enzymes (e.g., superoxide dismutase, catalase, and peroxidase) [35,36,37] and improves tolerance to osmotic stress. Potassium is also an integral part of many metabolic activities of the plants [25,38,39] and proper availability of potassium keeps the plants normal, even under drought stress, which ultimately leads to higher yield and water productivity. Samar et al. [40] demonstrated that foliar application of 1% K minimizes the negative effect of drought on wheat plants at all growth stages; improved the physiological performance and uptake of N, P, K and Ca but reduced Na uptake where grain filling stage being more responsive. Abdallah et al. [41] summarizes that potassium sulfate ameliorated the adverse effects of water stress, enhanced wheat plant growth by affecting biosynthesis of the plant's bioactive compounds, higher nutritional value, macronutrients (N, P, K, Ca), carbohydrate and protein percentage in the yielded grains.

Organic fertilizers are used to enhance soil quality and added essential nutrients for plant growth. The industrial by-products contain banana peels, equivalent to 40% of the total weight of fresh banana, generated as a waste product [42]. These are used as fertilizer or discarded in many countries as solid waste at large expense. Potential applications of banana peel depend on its chemical composition. Banana peel is a rich source of antioxidants; phenolic compounds, flavonoids; vitamin A as beta carotene, vitamin C, vitamin E and nutritional ingredients such as in dietary fiber, proteins, carbohydrates, essential amino acids, polyunsaturated fatty acids [43,44, 45,46, 47, 48]. Rebello et al. [49] have shown that banana peel extract is a rich source of total phenolics (29 mg/g as GAE), which are responsible for the very high antioxidant activity. Banana peels contain the three macronutrients i.e. Potassium, Nitrogen, and, Phosphorus as well as many micronutrients, which promote the growth of plants [44]. It contains common growth promoting substances, which may be involved (as foliar or soil applications) in the mechanism of induction of growth in various plant species [49]. Danish et al. [50] concluded that foliar application of 1% banana peel waste biochar are effective to mitigate chromium toxicity by decreasing its intake, improve chlorophyll contents and growth attributes in *Spinacia oleracea* L.

This study aimed to compare effect of potassium and banana peel in alleviating the deleterious effect of water deficit on soybean plants.

## 2. Materials and Methods

### *2.1. Plant material and growth conditions*

A trial was performed at a wire-house of the National Research Centre, Dokki, Cairo, Egypt (30°20' N; 31°53' E) during two summer season (2016 and 2017).

Seeds of soybean (*Glycine max* L.; cv. Giza 111) were obtained from Agricultural Research Centre, Ministry of Agriculture and Land Reclamation, Egypt. Granular ammonium sulphate [20.5 (w/w) % N] was applied at a rate of 40 kg N $ha^{-1}$, and single superphosphate [15% $P_2O_5$) was added at a rate of 60 kg $P_2O_5$ $ha^{-1}$ to each pot. These N and P fertilizers were mixed into the soil in each pot immediately before sowing.

Potassium sulphate and banana peel treatments were designed in a complete randomized block design with six replicates. Banana peels were collected from house hold kitchen and fresh fruit juice shops. The peels were shredded into small pieces of size approximately 1 $cm^2$; dried in shadow, open air and then undergo grind to fine particles. Potassium in the form of potassium sulphate was added to top of the soil at two rates 1.35 g/pot or 2.72 g/pot meanwhile finely dried and ground banana peel was added to top of the soil at two rates 5 g/pot or 10 g/pot.

Healthy soybean seeds (n = 10) were selected for uniformity by choosing those of equal size and of the same colour. The selected seeds were washed in distilled water, sterilized with 1% (v/v) sodium hypochlorite for approx. 2 min, washed thoroughly again in distilled water, and left to dry at room temperature (25$^o$C) for approx. 1 h. Ten, uniform, air-dried soybean seeds were sown along a centre row in each plastic pot (30 cm diameter) at a depth of 30 mm.

Ten day after sowing (DAS), soybean seedlings were thinned to five seedlings per pot and irrigated with equal volumes of tap water till 15 DAS.

Regarding irrigation, unstressed treatments were watered twice/week with tap water after 15 DAS from sowing and till the end of experiment, whereas water deficit treatments were watered once/week by tap water after 15 DAS from sowing and till the end of experiment.

Growth samples were collected at 45 after sowing to determine plant height; number of leaves; shoot and root dry weight/plant; relative water content and photosynthetic pigments.

At harvest, plants were collected to determine number of pods and seeds /plant; fresh and dry weight of pods /plant; weight of seeds /plant. The collected seeds were cleaned and grinded to estimate total carbohydrate; oil content, total phenolic content, flavonoids, tannins and antioxidant activity.

RWC was measured on the fully-expanded leaf in all treatments on the same leaves and same day. Measurements of RWC were performed on leaves collected and individual leaves were first removed from the stem with tweezers. A sharp razor blade was used to cut the leaf base. Leaves were then immediately weighed (Fresh weight). In order to obtain the turgid weight, leaves were floated in distilled water inside a closed petri dish for 6 h. After the imbibitions period, leaf samples were weighed, after gently wiping the water from the leaf surface with tissue paper. Leaf samples are then oven dried at 80 $^{0}$C for 24h and weighed (after being cooled down in a desiccators) to determine dry weight. All weighing is done to the nearest mg. All mass measurements were made using an analytical scale, with precision of 0.0001 g. At the end of the imbibitions period, leaf samples were placed in a pre-heated oven, at 80°C, for 48 h, in order to obtain the dry weight. Values of RWC were obtained, using the equation:

$$\text{RWC (\%)} = \frac{\text{Fresh weight - Dry weight}}{\text{Turgid weight - Dry weight}} \times 100$$

Chlorophyll *a*, chlorophyll *b*, and carotenoid concentrations (mg $g^{-1}$ FW) were estimated according to Moran [51].

Seed oil content was determined using Soxhlet apparatus and petroleum ether (40-60$^{o}$C) according to AOAC [52]. The defatted meals were used for further analyses. Total carbohydrates were determined according to Dubois *et al*. [53]. Total phenolic compounds were determined according to the method described by Zhang and Wang [54]. Total flavonoid contents were measured by the aluminum chloride colorimetric assay as described by Ordoñez *et al*. [55]. Tannins were determined using the modified vanillin hydrochloric acid (MV-HCl) as reported by Maxson and Rooney [56]. The free radical scavenging activity was determined according to Brand-Williams *et al*. [57] using the 1.1-diphenyl-2-picrylhydrazil (DPPH) reagent.

### *2.2. Statistical analysis*

All data were subjected to analysis of variance (ANOVA) for a randomized complete block design, after testing for homogeneity of error variances according to the procedure outlined by Gomez and Gomez [58]. Statistically significant differences between means were compared at $P \leq 0.05$ using Duncan's multiple range tests.

## 3. Results and Discussion

### *3.1. Growth parameters*

Water deficit condition significantly decreased the most investigated growth parameters and relative water content (Table 1). The observed reduction in plant height; shoot and root dry weights under drought stress might be due to lower production of photosynthates and decrease in gas exchange activities, $CO_2$ fixation cell damage by ROS [59,60,61]. On the other hand, potassium and banana peel treatments significantly increased the most investigated growth parameters and relative water content either under well-watered or water deficit conditions (Table 1). Banana peel treatments were more effective than potassium treatments either under well-watered or water deficit conditions. It is worthy to mention that 10 g/pot banana peel was the most pronounced treatments either under well-watered or water deficit conditions, since it increased shoot dry weight by 52.90% and 14.76%; root dry weight by 21.73% and 66.66% and relative water content by 20.17% and 17.67% relative to corresponding controls respectively.

**Table 1:** Effect of potassium or banana peel on some growth parameters of soybean plants grown under water deficit conditions

| Treatments | | Plant height (Cm) | Leaves number/plant | Shoot dry weight(g) | Root dry weight(g) | Relative water content (%) |
|---|---|---|---|---|---|---|
| Well Watered | WW | 54.5 b | 7.5 a | 1.55 c | 0.46 ab | 60.63 e |
| | K1 | 56.5 b | 7.5 a | 1.64 bc | 0.48 ab | 61.81 d |
| | K2 | 61.50 b | 8.0 a | 1.88 b | 0.53 ab | 67.75 c |
| | B1 | 59.50 b | 8.5 a | 2.24 a | 0.54 a | 68.99 b |
| | B2 | 74.00 a | 8.5 a | 2.37 a | 0.56 a | 72.86 a |
| water Deficit | WD | 33.00 d | 6.5 a | 1.49 c | 0.24 b | 50.87 i |
| | K1 | 38.0 cd | 7.5 a | 1.52 c | 0.30 ab | 50.62 i |
| | K2 | 41.00 c | 7.0 a | 1.59 bc | 0.39 ab | 56.83 g |
| | B1 | 42.00 c | 7.0 a | 1.68 bc | 0.37 ab | 52.55 h |
| | B2 | 44.00 c | 7.0 a | 1.71 bc | 0.40 ab | 59.86 f |

Mean values in each column followed by different lower-case-letter are significantly different by least-significant difference test (LSD) at 5%. K1: 1.35 g/pot; K2: 2.70 g/pot; B1: 5 g/pot; B2: 10 g/pot.

Potassium application alleviated the deleterious effect of water deficit and improving plant growth by maintaining stomatal regulation through osmotic adjustment for improved $CO_2$ fixation accountable for biosynthesis of photo-assimilates [62,63,64]. Further, Potassium (K) is also essential for the translocation of photoassimilates in root growth and root growth promotion by increased appropriate potassium supply was found to increase the root surface that was exposed to the soil as a result of increased root water uptake [62]. Lindhauer [65] reported that K nutrition increased plant total dry mass, leaf area along, with improved water retention in plant tissues under drought stress. The positive effects of potassium on water stress tolerance may be through the promotion of root growth accompanied by greater uptake of nutrients and water by plants [66].

The increments of all growth parameters of soybean plants under the effect of banana peel are in good agreement with those reported by Altaee [67] who observed that high levels of banana peel powder at 10 g/ plant was significantly increased all vegetative growth parameters of the plant (plant height, leaf number, leaf length), percentage of chlorophyll as well as the number and length of flowers. Likewise, The increase in the number of leaves can be explained by the fact that the banana peel contains the main nutrients such as nitrogen, phosphorus, potassium and calcium, which stimulate plant growth and development through its effect on the physiological processes such as photosynthesis and thus positively effect on the characteristics of vegetative growth. The promotive effect of banana peel on plant growth may be due to the presence of natural antioxidants as vitamins, flavonoids, phenolic compounds which is necessary for plants growth [44].

Under deficit water condition, relative water contents (RWC) of the leaf and leaf water potential also reduced, which had significant effect on photosynthesis [68,69]. The maintenance of plant water economy by potassium application in terms of a high RWC level under water deficiency condition could be ascribed to the supposed role of potassium in stomatal resistance, water use efficiency and lowered transpiration rate. These results are supported by Umar and Din [70], who reported that application of potassium improves RWC of plants under water stress conditions.

### *3.2. Photosynthetic pigments*

Water deficit conditions significantly decreased all components of photosynthetic pigments (Table 2). Drought inhibits or slows down photosynthetic carbon fixation mainly through limiting the entry of $CO_2$ into the leaf or directly inhibiting its metabolism [71] and accumulation of ROS which induces oxidative stress to proteins, membrane lipids and other cellular component [72]. Moreover, the inhibition in chlorophyll content in stressed plants might be due to the disorganization of thylakoid membranes, with more degradation than a synthesis of chlorophyll through the formation of proteolytic enzymes, like chlorophyllase, that is responsible for degrading chlorophyll and damaging the photosynthetic apparatus [73]. Ripley et al. [74] found that water stress might reduce photosynthetic assimilation by both stomatal and metabolic limitations.

**Table 2:** Effect of potassium or banana peel on photosynthetic pigments (mg/g fresh leaf)of soybean plants grown under water deficit conditions

| Treatments | | Chlorophyll a | Chlorophyll b | Carotenoid | Total photosynthetic pigments |
|---|---|---|---|---|---|
| **Well Watered** | WW | 2.87 cd | 0.88 cd | 0.49 cde | 4.00 cd |
| | K1 | 2.93 bcd | 0.88 cd | 0.50 cd | 4.08 bcd |
| | K2 | 3.07 bc | 0.94 bcd | 0.52 cd | 4.13 bcd |
| | B1 | 3.73 ab | 1.18 ab | 0.69 ab | 5.26 ab |
| | B2 | 4.30 a | 1.31 a | 0.81 a | 6.02 a |
| **water Deficit** | WD | 1.18 f | 0.41 f | 0.21 f | 1.70 f |
| | K1 | 1.87 ef | 0.59 ef | 0.34 ef | 2.64 ef |
| | K2 | 2.22 de | 0.71 de | 0.41 de | 3.15 de |
| | B1 | 3.22 bc | 1.00 bc | 0.58 bc | 4.54 bc |
| | B2 | 3.26 bc | 0.99 bc | 0.52 cd | 4.56 bc |

Mean values in each column followed by different lower-case-letter are significantly different by least-significant difference test (LSD) at 5%. K1: 1.35 g/pot; K2: 2.70 g/pot; B1: 5 g/pot; B2: 10 g/pot

Meanwhile, all potassium and banana peel treatments caused marked increases in total photosynthetic pigments either under well-watered or water deficit conditions (Table 2). Banana peel treatments were more effective in increasing photosynthetic pigments than potassium treatments either under well-watered or water deficit conditions. It is worthy to mention that 10 g/pot banana peel was the most pronounced treatments either under well-watered or water deficit conditions, since it increased total photosynthetic pigments by 50% and 168% relative to corresponding control respectively. The addition of potassium enhances photosynthesis and carbohydrate metabolism under drought stress [75,76], by improving the leaf internal $CO_2$ concentration and leaf stomatal conductance which regulates the stomatal opening. Asgharipour and Heidari [77] found that treatment with $K_2SO_4$ increased significantly the chlorophyll content with an increase in K supply and increase in the frequency of irrigation. In addition, potassium plays an important role in the formation of photosynthetic pigment by preventing decomposition of newly formed chlorophyll and δ-aminolevulinic acid (ALA) synthase formation [78]. These results indicate that the application of potassium is connected with the tolerance of soybean plants to water stress by enhancing the biosynthesis of photosynthetic pigments.

The promotive effect of banana peel on photosynthetic pigments could be attributed to the scavenging of reactive oxygen species by this antioxidant molecule and/or by increasing the antioxidant enzyme activity and promoting photosynthesis, maintaining enzyme activity [44]. Likewise, banana peel contains carotenoids that play a role as a free radical scavenger which, enhance their capacity to reduce the damage caused by ROS, which in turn increased chlorophyll content of such plants. Moreover, banana peel is characterized by essential elements that required in the structure of porphyrin, which is involved in the construction of chlorophyll and thereby increased production of chlorophyll.

### *3.3. Seed yield and yield components*

It is obvious that water deficit condition significantly decreased fresh and dry weight of pods/plant as well as seed yield/plant (Table 3). Water deficit condition decreased seed yield by 37.53% relative to well-watered condition. The adverse effects of drought stress on seed yield production are due to inhibition in cell expansion, alterations in plant metabolism and reduction in the activities of different metabolic enzymes such as enzymes in the Calvin cycle [79] as well as reduction in respiration, translocation, ion uptake, and levels of growth promoters [80].

**Table 3: Effect of potassium or banana peel on seed yield and yield components of soybean plant grown** under water deficit conditions

| **Treatments** | | **Number of pods/plant** | **Fresh weight of pods/plant (g)** | **Dry weight of pods/plant (g)** | **Number of seeds/plant** | **weight of seeds/plant (g)** |
|---|---|---|---|---|---|---|
| **Well Watered** | WW | 8.75 def | 2.33 cd | 1.43 cd | 9.0 cd | 1.19 d |
| | K1 | 11.0 cd | 3.19 c | 1.71 c | 13.0 bc | 1.49 c |
| | K2 | 16.0 b | 4.38 b | 2.70 a | 17.0 b | 2.45 ab |
| | B1 | 11.5 c | 4.80 b | 2.22 b | 14.0 bc | 2.21 b |
| | B2 | 19.0 a | 6.26 a | 2.85 a | 24.5 a | 2.74 a |
| **water Deficit** | WD | 6.25 f | 1.39 e | 0.83 f | 6.5 d | 0.77 e |
| | K1 | 7.75 ef | 1.80 de | 0.89 ef | 11.25 bcd | 0.83 e |
| | K2 | 7.95 ef | 3.09 c | 1.56 cd | 13.6 bc | 1.49 c |
| | B1 | 9.5 cde | 2.38 cd | 1.27 de | 12.75 bc | 1.30 cd |
| | B2 | 12.0 c | 2.98 c | 1.68 cd | 14.0 bc | 4 |

Mean values in each column followed by different lower-case-letter are significantly different by least-significant difference test (LSD) at 5%. K1: 1.35 g/pot; K2: 2.70 g/pot; B1: 5 g/pot; B2: 10 g/pot

On the other hand, most of applied treatments significantly increased soybean seed yield and yield components either under well-watered condition or water deficit condition relative to corresponding controls. It was noted that banana peel treatments alleviate the harmful effect of water deficit on soybean yield and yield components more than potassium treatments either under well-watered condition or water deficit condition relative to corresponding controls. 10 mg/pot banana peel was the most optimum treatments in increasing seed yield by 130% under well-watered condition and by 276% under water deficit condition relative to corresponding controls and the effect was more prominent under water deficit condition than well-watered condition.

Wang *et al*. [25]; Abbasi, et al. [38]; Soleimani [39] mentioned that potassium plays an important role in many metabolic activities of plants and proper availability of potassium keeps the plant nearly normal even under drought which ultimately leads to higher yield. Potassium application caused higher stomatal regulation, stimulated translocation of photosynthates from source to sink and increased water uptake could, presumably, lead to higher dry matter production, root growth, number of grains and their weights under drought stress conditions [25,62]. Ul-Allah et al. [81] stated that potassium application improved maize yield traits and water productivity under both normal and water stress conditions but effect was more prominent under water stress conditions than normal conditions. Amanullah *et al*. [82]

reported that foliar and soil applied potassium improved the growth, yield, and yield components of maize under drought stress conditions due to an improvement in osmolyte accumulations, activation of antioxidants, or improved sugar metabolism which improves the grain weight ultimately resulting in better grain yield and water productivity. Ashraf *et al*. [83] found that the application of $K_2SO_4$ stimulates wheat grain yield by improving growth conditions. The increase in yield and its components was due to the role of K for enhancing different enzyme activation, photosynthesis, protein synthesis, osmoregulation, energy transfer, stomatal movement, cation-anion balance, and stress resistance [25]. Bakry et al. [84] stated that exogenous application with banana peel extract at 500 mg/l was the most effective treatment in increasing quinoa yield due to its antioxidant ability [85].

### *3.4. Chemical composition of the yielded seeds*

It is clear that water deficit condition caused significant decreases in carbohydrate content, oil content, total phenolic content and antioxidant activity accompanied by significant increases in flavonoid and tannins in the yielded seeds relative to well-watered condition (Table 4). Contrary to the results reported according to water deficit condition, all applied treatments either potassium or banana peel caused significance increases in all biochemical constituents of the yielded seeds under investigation except tannins content that showed reduction under all applied treatments. 10 g/pot banana peel was the most pronounced treatments in alleviating deleterious effect of water deficit on the biochemical constituents of the yielded seeds.

**Table 4:** Effect of potassium or banana peel on some biochemical constituents of the yielded soybean seeds under water deficit conditions

| Treatments | | Carbohydrate % | Oil % | Phenolic content % | Flavonoid (mg/g) | Tannins (mg/100g) | DPPH% |
|---|---|---|---|---|---|---|---|
| Well Watered | WW | 26.75 h | 19.55 d | 1.91 f | 6.50 f | 16.38 a | 32.53 e |
| | K1 | 30.65 d | 23.70 b | 2.02 e | 6.91 e | 15.38 c | 35.59 b |
| | K2 | 32.39 b | 25.43 a | 2.10 e | 7.90 c | 15.09 e | 37.94 a |
| | B1 | 31.53 c | 24.03 b | 2.08 e | 7.05 e | 15.35 cd | 35.21 b |
| | B2 | 33.34 a | 25.83 a | 2.32 d | 8.02 c | 14.60 f | 38.07 a |
| water Deficit | WD | 25.23i | 18.28 e | 2.65 b | 7.37 d | 16.10 b | 31.03 f |
| | K1 | 27.40 g | 19.88 d | 2.39 cd | 8.29 b | 15.29 cde | 33.51 d |
| | K2 | 29.70 e | 22.9 c | 2.45 c | 9.03 a | 15.14 de | 34.10 cd |
| | B1 | 28.06 f | 19.77 d | 2.91 a | 8.4 b | 15.22 cde | 33.69 d |
| | B2 | 30.45 d | 22.64 c | 2.90 a | 9.1 a | 15.11 e | 34.54 c |

Mean values in each column followed by different lower-case-letter are significantly different by least-significant difference test (LSD) at 5%. K1: 1.35 g/pot; K2: 2.70 g/pot; B1: 5 g/pot; B2: 10 g/pot

Water stress decreased the photosynthetic pigments concentration in leaves which in turn it leads to less accumulation of carbohydrates in mature leaves and consequently may decrease the rate of transport of carbohydrates from leaves to the developing seeds [86]. Potassium also plays key roles in sugar metabolism and sugar remobilization under drought stress [87,88].

The reduction in the oil content under drought stress could be due to oxidation of some of the polyunsaturated fatty acids [89]. Improved achene oil quantity and quality by foliar K application might be the fact of its positive role in enzymes activation and terpene production [90]. Saif Ullah et al. [91]

observed that treated *Narcissus Narcissus daffodil* L plant with 10 g/ plant of banana peel powder gave the best results in the percentage of oil.

Total phenolic contents in oilseeds are very important for the oxidative stability of the polyunsaturated fatty acids of oils and indicative of antioxidant activity [92,93,94]. Increase in phenolic contents in different treatments under osmotic stress have been reported in sunflower cultivars plants [95]. This increase may be due to total phenols role to play a significant mechanism in regulation of plant metabolic processes [96]. Moreover, phenols act as a substrate for many antioxidants enzymes, so, it mitigates the water stress injuries [97]. In addition, the phenolic compounds have antioxidant role of as free radical scavenger through their reactivity as electron or hydrogen donor, to stabilize and delocalize the unpaired electron, and from their role as transition metal ions chelator [98]. Also, Rivero *et al*. [99] recorded an accumulation of phenolic compounds in response to abiotic stress.

Flavonoids are secondary metabolites of phenolic nature which play important roles in the protection of plants against environment stress [100]. Ali et al. [93] indicated that water stress significantly increased the flavonoids contents in maize plants. Meanwhile, the decreases in antioxidant activity under drought stress are in agreement with Ali et al. [94] who reported that the 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging activity, decreased significantly in maize due to drought stress.

Phenolic compounds and flavonoids detected in banana peel act as antioxidants via scavengers' free radicals, ROS, and RNS [101] and the antioxidant activity of the banana peel were evaluated by hydroxyl radical scavenging activity [102]. The increases in total phenols and total flavonoids lead to increases in antioxidant activity [103].

## Conclusion

It is obvious that banana peel treatment at 10 g/pot was the most pronounced treatment either under well-watered conditions or under water deficit conditions.

## Disclosure statement:

*Conflict of Interest:*

The authors declare that there are no conflicts of interest.

*Compliance with Ethical Standards:*

This article does not contain any studies involving human or animal subjects.

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