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Effects of Potassium Foliar Spray and Water Stress on Mungbean (Vigna Radiata L.) Growth

Fadhil Alaywe Atiyah Al-Rubaiee [1]

[1] Department of Curriculum Development and Examination – Ministry of Education, Iraq

Abstract: An experiment was carried out by using pots during the growing season of 2017 in a private nursery in Baghdad governorate to study the effect of three concentrations of potassium (K2SO4) (0, 100, and 200) mg. L-1 and three treatments of water stress were irrigation every three days (control), irrigation every sex days, and irrigation every nine days, and their interaction on growth and yield of Vigna radiata L. plant, The experiment was designed according to a Completely Randomized Design (CRD) with three replications.

The results showed that the effect of water stresses especially from nine days significant reduction in the rates of studied characteristics: plant height, dry weight, pod number, pod length, seed number, seed weight, chlorophyll content, nitrogen percentage, phosphorus percentage, and potassium percentage; by 19.5%, 19.40%, 24%, 4.01%, 19%, 8.43%, 4.72%, 18.40%, 30%, and 22% compared with control respectively. while the potassium-sparing showed a significant increase in the rates of studied characteristics, especially a concentration of 200 mg. L-1, the plant height by 60.54%, dry weight by 115%, pods number by 72%, pods length by 55.75%, seeds number by 76.6%, seeds weight by 20.78%, chlorophyll content by 58.70%, nitrogen percentage by 31.84%, phosphorus percentage by 176% and potassium percentage by 40% compared with control. The results showed a significant effect of interaction between both factors in all studied characteristics especially concentration of potassium 200 mg. L-1 and water stress sex days.

Keywords: mungbean ; potassium; water stress; growth parameters.

During the vegetative growth period; water is the most important factor determining crop growth and its impact on plant morphological and physiological characteristics, as a consequence, if freshwater supplies are limited or inadequate as a result of high temperatures and climatic variability, Iraq suffers from this, In addition to a lack of rain and a reduction in the levels of the Tigris and Euphrates rivers as a result of dam building on their two sources, as a result, agricultural fields are impacted more severely, drought is one of the non-biotic water stresses specific to plant growth and productivity, especially in dry and semi-arid areas[1, 2]. drought negatively affects crop growth by affecting the physiological and biochemical processes of the plant, inhibiting the division and elongation of cells [3, 4], photosynthesis, transpiration, dissolved accumulation, and hormonal imbalance, including the production of the effective oxygen group Reactive oxygen (ROS), which destroys proteins and cellular membranes [5] and a decrease in the chlorophyll content of the plant[6], which affects the growth of the plant. It has been found that water stress leads to a decrease in the number of branches, leaf number, leaf area, and plant height [7, 8], a decrease in pod number and length, and seeds number in pods [9],

Adopted many agricultural methods to reduce the negative effects of water stress on the plant, including the use of fertilizers, especially potassium, which is important in increasing the plant's tolerance to water stress by increasing the osmotic pressure of cells and controlling the movement of opening and closing of the stomata, which prevents the early wilting of plants exposed to water stress [10]. Potassium activates more than 75 enzymes that contribute to the completion of many important vital processes in the plant, including the process of photosynthesis, protein building, osmotic regulation, stomata movement, and stress resistance [11, 12], It has been found that potassium maintains a high water content in the plant's tissues even under extreme water stress conditions by creating a necessary inclination for the movement of water from wood towards the leaves and then increasing the leaves' water content [13,14].

Vigna radiata L. is an important legume and forage crop, a summer grassy plant, its life cycle is short (70-90 days), its height is 25-125 cm, its root and low depth in the soil, grown in most provinces of Iraq for the importance of its seeds It is a cheap source of protein-rich lysine, which is lacking in many other grains[15] as well as its importance in improving soil properties and using it as green feed for animals [16, 17]. The current study aims to find out the effect of potassium spraying to mitigate the effects of water stress on the growth and yield of the *Vigna radiata* L. plant.

Materials and methods

he experiment was carried out in a private nursery in Baghdad governorate for the growing season of 2017 using pots with a capacity of 8 kg of soil, to study the effect of potassium spraying, water stress, and their interaction on some phenotypic and physiological characteristics and the yield components of the *Vigna radiata* L. plant. The experiment was designed according to Completely Randomized Design (CRD) with three replications. The seeds were sown on 26/6/2017 at a rate of 15 seeds per pot, then the seedlings were reduced to 10 seedlings. The pots were watered daily as needed until the appearance of the leaves 4-6. Then the plants were treated with the following treatments:

1. water stress, which includes watering every three days (counted as a control treatment), watering every six days (6 days), and watering every nine days (9 days).

2. Spraying with two concentrations of potassium sulfate (K_2SO_4) (100 and 200 mg.L^{-1}) as a source of potassium, as the stock solution of potassium sulfate was prepared by taking a certain weight of the substance in a certain volume of distilled water and sufficient quantities to spray plants until wet. Spraying early in the morning with a 1-liter hand sprinkler with the addition of a solution of cleaning fluid as a diffuser to ensure complete wetness. As for the control plants (0), they were sprayed with distilled water only. The spraying took place in two periods, the first on 1/8/2017 and the second on 15/8/2017.On 27/8/2017, samples were taken from the shoot of five plants for each experimental unit; Some traits such as plant height were studied by taking the rated height of the whole plant and the shoot dry weight after drying the plants in an electric oven at a temperature of 65°C until the weight was stable, and some physiological growth indicators were also studied, including estimating the percentage of some nutrients of the shoot total as they were crushed the samples were dried, and a known weight was taken from them and digested according to the method[18]. Then the percentage of nutrients was estimated; Nitrogen was estimated using the *Kjeldahl* apparatus according to the method [19], phosphorous was estimated using the Spectrophotometer according to the method [20], and potassium was estimated using the Flamephotometer and according to the method [21]. The total chlorophyll content of plant leaves was estimated using the Spad-502 chlorophyll measuring device by taking three readings of several leaves for each experimental unit and then according to the rate for them.

The remaining five plants were harvested on 6/10/2017 and some of the characteristics of the yield components, including the number of pods, pod length, number of seeds per pod, and seed weight.

The results were analyzed statistically according to the design of the experiment according to the statistical program using the lowest significant difference LSD at a probability level of 0.05 [22].

Results and discussion

The results in Table (1) indicated that there were significant differences in the rate of plant height when it was exposed to water stress, as it decreased significantly during the nine-day irrigation period, by 19.5% compared to the control treatment, while the rate of plant height increased significantly when spraying with potassium, an increase of 26.18 % and 60.54% at 100 and 200 mg. L^{-1} compared with control respectively, while the interaction between both factors was significant, The highest value of plant height was 40.40 cm at a concentration of 200 mg. L^{-1} and the irrigation period to six days, while the lowest value is 18.13 cm at concentration 0, and the irrigation period is nine days.

Table 1. The effect of water stress, potassium, and their interaction on plant height (cm).

potassium mg. L^{-1}	**water stress(day)**			**Mean**
	3	**6**	**9**	
0	20.13	25.23	18.13	21.16
100	26.90	31.07	22.13	26.70
200	35.40	40.40	26.10	33.97
Mean	27.48	32.23	22.12	
LSD 0.05	water stress = 0.20 potassium con.= 0.20 Interaction = 0.347			

The negative effect of water stress on the rate of plant height (Table 1) led to a significant decrease in the shoot dry weight of the plant; As the results indicated in Table (2) the rate of shoot dry weight decreased significantly by 19.40% during the nine-day irrigation period compared to the control treatment, but when the plant was treated with potassium, the dry weight rate increased by 65.92% and 115% when spraying 100 and 200 mg. L^{-1} compared with control respectively. The interaction between the two study factors was significant, and the highest dry weight value was 7.83 g at a concentration of 200 mg. L^{-1} and the irrigation period was 6 days, while the lowest value was 2.27 g for concentration 0, and a dry period of 9 days.

Table 2. The effect of water stress, potassium, and their interaction on shoot dry weight (g).

potassium mg. L^{-1}	**water stress(day)**			**Mean**
	3	**6**	**9**	
0	3.23	3.83	2.27	3.11
100	5.40	5.87	4.20	5.16
200	6.53	7.83	5.73	6.70
Mean	5.05	5.84	4.07	
LSD 0.05	water stress – 0.210 potassium con. = 0.210 Interaction=0.363			

The results indicated in Table (3) that there were significant differences in the rate number of pods. The rate number of pods decreased during 9-day drought stress by 24% compared to the control treatment, while the rate number of pods increased significantly with an increase in the potassium concentration by 24% and 72% at the concentration of 100 and 200 mg.L^{-1} compared with control respectively. As for the interaction between the study factors, it was significant. The highest value of the number of pods was 17.67 pods at a concentration of 200 mg. L^{-1} and the irrigation period was 6 days, the lowest value was 6.67 pods for concentration 0 and the irrigation period was 9 days.

Table 3. The effect of water stress, potassium, and their interaction on pod number.

potassium mg. L^{-1}	water stress(day)			Mean
	3	6	9	
0	8.00	10.33	6.67	8.33
100	10.00	12.33	8.67	10.33
200	15.33	17.67	10.00	14.33
Mean	11.11	13.44	8.45	
LSD 0.05	water stress = 0.527 potassium con. = 0527 Interaction = 0.912			

The rate of pod length was also reduced by the effect of water stress. The results in Table (4) indicated a significant decrease for this trait by 4.01% during the nine-day irrigation period compared to the control treatment, while the rate pod length increased significantly when increasing the potassium concentration by 32.74% and 55.75% at the concentration of 100 and 200 mg.L^{-1} compared with control respectively. As for the interaction between the study factors, it was significant. The highest value for this characteristic was 12.33 cm at 200 mg. L^{-1} and the irrigation period is six days, while the minimum value is 6.00 cm at concentration 0, and the irrigation period is nine days.

Table 4. The effect of water stress, potassium, and their interaction on pods length (cm).

potassium mg. L^{-1}	water stress(day)			Mean
	3	6	9	
0	6.33	8.00	6.00	6.78
100	8.67	10.33	8.00	9.00
200	9.67	12.33	9.67	10.56
Mean	8.22	10.22	7.89	
LSD 0.05	water stress= 0.565 potassium con. = 0.565 Interaction = 0.978			

There was also a decrease in the number of seeds per pod due to the impact of water stress; Table (5) indicated that the rate number of seeds decreased significantly when stressing the drought for nine days, by 19% compared to the control treatment, while the rate number of seeds increased significantly when treated with potassium by 53.3% and 76.6% at a concentration of 100 and 200 mg.L^{-1} successively compared to the control treatment. As for the interaction between the study factors, it was significant, and the highest value for this characteristic was 10.33 seeds at a concentration of 200 mg. L^{-1} and water stress for six days, the lowest value of 3.33 seeds at concentration 0, and water stress for nine days.

Table 5. The effect of water stress, potassium, and their interaction on seed number.

potassium mg. L^{-1}	water stress(day)			Mean
	3	6	9	
0	4.67	6.33	3.33	4.78
100	6.67	9.33	6.00	7.33
200	8.33	10.33	6.67	8.44
Mean	6.56	8.66	5.33	
LSD 0.05	water stress = 0.527 potassium con.= 0.527 Interaction= 0.912			

The results in Table (6) showed that there was a significant decrease in the rated weight of seeds in the pod by 8.43% at 9-day water stress compared to the control treatment, and the rate seed weight increased significantly due to the effect of potassium spraying by 15.58% and 20.78% at concentration 100 and 200 mg. L^{-1} compared with control respectively, as for the interaction between the study factors, it was significant. The highest seed weight was 1.11 g at 100 mg. L^{-1} and water stress for six days, and the lowest value of 0.70 g at concentration 0, and water stress for nine days.

Table 6. The effect of water stress, potassium, and their interaction on seeds weight.

potassium mg. L^{-1}	water stress(day)			Mean
	3	6	9	
0	0.78	0.83	0.77	0.77
100	0.80	1.11	0.75	0.89
200	0.92	1.04	0.83	0.93
Mean	0.83	0.99	0.76	
LSD 0.05	water stress = 0.009 potassium con.= 0.009 Interaction= 0.016			

Also, there was a significant decrease in the chlorophyll content of the leaves of the mungbean plant due to the effect of stress. The results in Table (7) indicated a decrease in the rate chlorophyll content at 9-day water stress and a decrease of 4.72% compared to the control treatment, and the results of the same table also showed a significant increase in the rate chlorophyll content, with an increase in potassium concentration by 32.96% and 58.70% at concentration 100 and 200 mg.L^{-1} successively compared to the control treatment, and there was a significant increase in the chlorophyll content due to the interaction between the study factors. The highest chlorophyll content was 12.62 at 200 mg. L^{-1} and the dry period is six days the lowest value is 6.09 at concentration 0 and the dry period is nine days.

Table 7. The effect of water stress, potassium, and their interaction on chlorophyll content.

potassium mg. L^{-1}	water stress(day)			Mean
	3	6	9	
0	7.11	8.01	6.09	7.07
100	8.96	10.35	8.89	9.40
200	10.61	12.62	10.43	11.22
Mean	8.89	10.39	8.47	
LSD 0.05	water stress = 0.153 potassium con.= 0.153 Interaction = 0.265			

The results in Table (8) showed that there was a significant decrease in the nitrogen percentage in the shooting part of the mungbean plant by 18.40% when stressing water for nine days compared with the control treatment, while the rate of nitrogen percentage increased significantly when treated with potassium by 17.55% and 31.84% when concentration is 100 and 200 mg. L^{-1} on compared with control respectively. There was a significant increase in the percentage of nitrogen as a result of the interaction between the study factors, and the highest value was 3.61% at a concentration of 100 mg. L^{-1} and water stress for six days and the lowest value of 1.89% at concentration 0 and water stress for nine days.

Table 8. The effect of water stress, potassium, and their interaction on nitrogen percentage.

potassium mg. L^{-1}	water stress(day)			Mean
	3	6	9	
0	2.66	2.80	1.89	2.45
100	2.88	3.61	2.16	2.88
200	3.11	3.57	3.00	3.23
Mean	2.88	3.33	2.35	
LSD 0.05	water stress = 0.014 potassium con. =0.014 Interaction= 0.023			

Also, there was a significant decrease in the rate of phosphorus percentage due to the effect of water stress by 30% when stressing water 9 days compared with the control treatment, and this is indicated in table (9), while there was a significant increase in the percentage of phosphorus when treated with potassium by 129% and 176%. At a concentration of 100 and 200 mg. L^{-1} was sequentially compared to the control treatment, and there was a significant increase in phosphorus percentage as a result of the interaction between the study factors. The highest value of phosphorus percentage was 0.53% at 200 mg. L^{-1}, water stress for six days, and the lowest value of 0.14% at concentration 0, and water stress for nine days.

Table 9. The effect of water stress, potassium, and their interaction on phosphorus percentage.

potassium mg. L^{-1}	water stress(day)			Mean
	3	6	9	
0	0.20	0.18	0.14	0.17
100	0.48	0.38	0.31	0.39
200	0.51	0.53	0.39	0.47
Mean	0.40	0.36	0.28	
LSD 0.05	water stress = 0.013 potassium con.= 0.013 Interaction= 0.023			

Table (10) shows that the rate of potassium percentage decreased significantly due to the effect of water stress, by a decrease of 22% when stressing water 9-day compared with the control treatment, while the rate of potassium percentage increased when spraying plants with potassium by 17.5% and 40% at concentration 100 and 200. mg. L^{-1} was sequentially compared to the control treatment, and there was a significant increase in the potassium percentage as a result of the interaction between the study factors. The highest value of potassium percentage was 2.59% at 200 mg. L^{-1} and water stress for six days, and the lowest value of 1.51% at concentration 0, and water stress for nine days.

Table 10. The effect of water stress, potassium, and their interaction on potassium percentage.

potassium mg. L^{-1}	water stress(day)			Mean
	3	6	9	
0	1.77	1.52	1.51	1.60
100	2.18	1.89	1.56	1.88
200	2.33	2.59	1.81	2.24
Mean	2.09	2.00	1.63	
LSD 0.05	water stress = 0.013 potassium con.= 0.013 Interaction= 0.023			

The decrease in the rates of the studied plant characteristics is due to the negative impact of water stress on the functional processes in the plant, especially at the stages of vegetative growth; Whereas, whereas the presence of water is necessary for the system of the plastid thylakoids; Its deficiency causes an imbalance in the photolysis of water molecules and the accumulation of free radicals from the Reaction Oxygen Species so that the CO_2 fixation process and the accumulation of dry matter are halted [23, 24], Reduction in the production of plant pigments, including chlorophyll, thus reducing its content in plants [25]. As well as the effect of water stress in disturbing the hormonal system of the plant; The internal concentration of gibberellin decreases, which reduces the root growth and thus the area of nutrient absorption. ABA accumulates within the mesophyllic tissue of the leaf and displaces potassium ions, which affects the control mechanism of the stomatal system with the shrinking of the leaf area of the plant, thus the fixation of carbon dioxide stops [26, 27], as well as It reduces cell division and expansion, especially in the apical regions [28]. In addition to the drying out of the flower bed and not holding it, and thus its abortion; Because of the lack of nutrients from the source to the sink, which leads to an imbalance in protein structure with an imbalance in the growth of pods and seeds, which reduces their number or reduces their growth [29, 30].

As for the positive effects of potassium treatment on the rates of the studied traits, it may be attributed to its role in mitigating the negative effects of water stress by maintaining the water balance [31, 32], In delaying leaf aging, which maintains leaf activity in the photosynthesis process for the longest period[33], as well as its role in other vital activities such as protein building, osmotic regulation, and control of the mechanism of stomatal opening and closing; This reduces water loss through transpiration, especially in cases of water stress for plants [34], and in improving root growth [35]; This improves the absorption or processing of the plant with nutrients such as nitrogen and phosphorous, which accompany the addition of potassium, especially in the critical stages of the plant's life.

CONCLUSION

According to the findings, potassium plays an important role in increasing plant tolerance to water stress by increasing translocation and maintaining water balance. We can conclude from this study that potassium supplementation at 200 mg.L^{-1} is effective.

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