تأثير دفعات الرش على أداء محصول ومكونات البطاطس

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The Effect of sprayed batches on the performance of Potato Yield and Components

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Abstract

the application of nutrients or foliar feeding is one of the methods to eliminate the nutritional needs of plants. To investigate the effect of different messengers on *Solanum tuberosum var. Riviera.* Riviera, a study was conducted in a randomized complete block design with three replications. Experimental treatments include: potassium phosphate (1/1000 CC), potassium silicate (1.5/1000 CC), hydrogen peroxide (5 µM), potassium silicate (1.5/1000 CC) + potassium phosphate (1/1000 CC), potassium phosphate (1/1000 CC) + Hydrogen peroxide (5 µM), potassium silicate (1.5/1000 CC) + hydrogen peroxide (5 µM), potassium phosphate (1/1000 CC) + potassium silicate (1.5/1000 CC) + hydrogen peroxide (5 µM) and control treatment (without spraying). The foliar application was done simultaneously with the appearance of flowers in the plant and 20 days before potato tuber harvest. The results showed that foliar application of potassium silicate + hydrogen peroxide + potassium phosphate increased plant height by more than 15% compared to the control treatment and record the highest height in the plant in this experiment. Also, foliar application of potassium silicate improved the dry weight of the plant by 31%, compared to the control treatment. Foliar application of potassium phosphate alone and in combination with potassium silicate and this combination: potassium silicate + hydrogen peroxide + potassium phosphate was able to increase the tuber weight in the plant by 8.66%, 11.41%, and 14.17%, respectively, compared to the control treatment. Also, plant performance under foliar application of potassium phosphate increased by 18.27% and hydrogen peroxide by 18.47%. In general, it can be said that the use of a combination of potassium silicate + potassium phosphate + hydrogen peroxide, and also foliar application of the plant using potassium phosphate alone in the potato is recommended to improve the growth traits.

Keywords: Solanum tuberosum var. Riviera, nutrients, foliar feeding, potato tuber.

الملخص:

يعد استخدام المغذيات أو التغذية الورقية إحدى طرق القضاء على الاحتياجات الغذائية للنباتات. لفحص تأثير مختلف أنواع دفعات الرش على Solanum tuberosum var.Riviera .Riviera ، تم إجراء دراسة على تصميم القطاعات العشوائية الكاملة بثلاثة مكررات. تشمل العلاجات التجريبية: فوسفات البوتاسيوم (1000/1 سم مكعب) ، سيليكات البوتاسيوم (1.5 / 1000 سم مكعب) ، بيروكسيد الهيدروجين (5 ميكرومتر) ، سيليكات البوتاسيوم (1.5 / 1000 سم مكعب) + فوسفات البوتاسيوم (1000/1 سم مكعب) ، فوسفات البوتاسيوم (1000/1 سي سي) + بيروكسيد الهيدروجين (5 ميكرومتر) ، سيليكات البوتاسيوم (1.5 / 1000 سم مكعب) + بيروكسيد الهيدروجين (5 ميكرومتر) ، فوسفات البوتاسيوم (1000/1 سم مكعب) + سيليكات البوتاسيوم (1.5 / 1000 سم مكعب) + بيروكسيد الهيدروجين (5 ميكرومتر) ومعالجة التحكم (بدون رش). تم تطبيق الأوراق بالتزامن مع ظهور الأزهار في النبات وقبل 20 يومًا من حصاد درنات البطاطس. أظهرت النتائج أن إضافة سليكات البوتاسيوم + بيروكسيد الهيدروجين + فوسفات البوتاسيوم على الأوراق أدت إلى زيادة طول النبات بأكثر من 15٪ مقارنة بمعاملة المقارنة وسجل أعلى ارتفاع في النبات في هذه التجربة. كما أدت إضافة سيليكات البوتاسيوم على الأوراق إلى تحسين الوزن الجاف للنبات بنسبة 31٪ مقارنة بمعاملة المقارنة. استطاع التطبيق الورقي لفوسفات البوتاسيوم وحده وبالاقتران مع سيليكات البوتاسيوم وهذه التركيبة: سيليكات البوتاسيوم + بيروكسيد الهيدروجين + فوسفات البوتاسيوم زيادة وزن الدرنات في النبات بنسبة 8.66٪ ، 11.41٪ ، و 14.17٪ على التوالي ، مقارنة بـ علاج السيطرة. كما زاد أداء النبات عند الاستخدام الورقي لفوسفات البوتاسيوم بنسبة 18.27٪ وبيروكسيد الهيدروجين بنسبة 18.47٪. بشكل عام ، يمكن القول أن استخدام مزيج من سيليكات البوتاسيوم + فوسفات البوتاسيوم + بيروكسيد الهيدروجين ، وكذلك الاستخدام الورقي للنبات باستخدام فوسفات البوتاسيوم وحده في البطاطس يوصى به لتحسين سمات النمو.

الكلمات المفتاحية: بطاطس ريفييرا ، العناصر الغذائية، التغذية الورقية ، درنة البطاطا.

Introduction

The nutritional importance of potato in the world is not hidden from anyone (Haase *et al.*, 2007). Potato is a rich source of carbohydrates, proteins, and essential human amino acids and after grains such as wheat, rice, barley, and corn are very important in human nutrition (Mousavi, 2011). More importantly, potatoes are a source of starch (carbohydrates) and also some minerals such as potassium and calcium (Mitiku *et al.*, 2019). Potato tubers can be used fresh or indirectly after processing, freezing, and drying (Boras *et al.*, 2006). Potato agricultural product, due to their importance in the food basket of people, for high performance and quality, needs to pay attention to the optimal use of different types of chemical and organic compounds (Defauw *et al.*, 2012). Potato is one of the most widely consumed food products in human nutrition. This product, despite its high performance per unit area, is very input and needs high nutrition. Therefore, understanding the plant's nutritional needs and matching the available nutrients with the plant's nutritional needs at different stages of growth has a major impact on tuber performance, specific gravity, and other quality indicators (Lang *et al.*, 1999). The low performance of agricultural products in many countries is generally associated with soil nutrient deficiencies (Ziaeian, 2003). Farmers are trying to increase crop production by eliminating nutrient deficiencies in the soil and using proper management methods (Rehman *et al.*, 2002). Chemical compounds play an essential role in improving the performance and quality of potato tubers (Rizk *et al.*, 2013). Providing sufficient nutrients in the soil requires the use of various chemical compounds (Scheiner *et al.*, 2002). According to previous findings, potatoes need high amounts of nitrogen, phosphorus, and potassium for the economic production of tubers (Regmi *et al.*, 2002). Improvement in potato plant performance and growth indexes due to nitrogen uses has been reported (Motalebifard, 2019). The use of potassium in this plant has also improved the fresh and dry weight of tubers and plants (Ghanbari *et al.*, 2007) and increased performance in the plant (Abdul Hannan *et al.*, 2011). Various studies have reported the positive effect of potassium in various forms of potassium sulfate, potassium oxide, potassium nitrate, potassium silicate, potassium chloride, and monopotassium in improving the growth traits of potato plants and increasing their performance (Salim *et al.*, 2014; Haddad *et al.*, 2016; Molahoseini and Jalali, 2017). In addition, foliar application of potatoes with potassium silicate (5 mM) led to a significant increase in chlorophyll b and soluble sugar in plant leaves (Talebi *et al.*, 2015). It has been shown that the use of phosphorus (60 kg/ha) in potatoes increased the number of marketable tubers (Zelalem *et al.*, 2009). In other studies, improvement of vegetative parameters, tuber performance, and quality under the influence of phosphate compounds has been reported (Aivazlo *et al.*, 2010; Abd EL-Nabi *et al.*, 2013). Hydrogen peroxide acts as a messenger molecule in the signaling pathways and leads to increased plant tolerance to abiotic stresses at low concentrations (Almedia *et al.*, 2005). According to previous research, low concentrations of hydrogen peroxide have a very significant and positive effect on plant growth, plant growth regulators, antioxidant enzyme activity, fruit performance, and tomato quality (Orabi *et al.*, 2015). The use of hydrogen peroxide at a concentration of 20 mM has been able to cause rapid and simultaneous germination of microtubules in potatoes; While its high concentrations (40 to 60 mM) caused non-uniformity in germination (Mani *et al.*, 2013). The use of hydrogen peroxide at a concentration of 1% in the potato plant affected the physiological processes of the leaves (Szpunar-Krok *et al.*, 2020). Also, in the *Ficus deltoidea* var. Deltoidea foliar application of hydrogen peroxide at concentrations of 16 and 30 mM once a week, increased the growth and accumulation of minerals (Nurnaeimah *et al.*, 2017). Consumption of potatoes and their products is increasing in the world; for this reason, more attention to innovation in potato production and improving quality features with increased performance is inevitable. It is very useful to know the concentration of different nutrients in this product and by enriching high-consumption foods such as potatoes, an effective step can be taken toward food safety and health. As a result, this study was conducted to investigate the effects of different messengers on the performance and performance components of potatoes.

Materials and methods

To investigate the foliar application of some chemical compounds on *Solanum tuberosum var.Riviera* . Riviera, a study was conducted in the city of Bābilim in Iraq in a randomized complete block design with three replications. Experimental treatments include: potassium phosphate (1/1000 CC), potassium silicate (1.5/1000 CC), hydrogen peroxide (5 μM), potassium silicate (1.5/1000 l) + potassium phosphate (1/1000 CC), potassium phosphate (1/1000 CC) + Hydrogen peroxide (5 μM), potassium silicate (1.5/1000 CC) + hydrogen peroxide (5 μM), potassium phosphate (1/1000 CC) + potassium silicate (1.5/1000 CC) + hydrogen peroxide (5 μM) and control treatment (without foliar application). Initially, tubers with a diameter of 40 to 50 mm were removed from the refrigerator (4 °C) twenty days before planting and placed in the dark at a temperature of 15-20 °C for bud growth. The tubers at the time of planting had 3 to

5 green buds that were at least 3 to 5 mm long. Before planting the tubers in the soil, the fungicides Iprodin (35%) and Carbendazim (5%) were used. Finally, potato tubers were planted in plots that were four meters wide and five meters long, and each had four planting lines. Potato planting lines were 75 cm apart and each tuber was planted on the planting line at a distance of 20 cm from each other (Fig 1). For the better establishment of the plant in the soil, the soiling operation in this plant was performed twice during the growth process of the plant; the first stage was done when the plant had a height of 10-15 cm, and the second stage was done before flowering. In the first stage, foliar application of plants was done simultaneously with the appearance of flowers in the plant, and in the second stage, 20 days before potato tuber harvest (Fig 1). At the end of the experiment and after collecting the tubers, plant height, shoot dry weight, tuber weight, and plant performance was measured. Also, the number of tubers and the average number of tubers with sizes between 20 to 30 mm, 30 to 40 mm, 40 to 50 mm, 50 to 60 mm, and more than 60 mm per plant were counted. Statistical analysis of experimental data was performed using JMP-8 statistical software and a comparison of mean data was performed using an LSD test at a 5% level.

Fig 1. The process from planting to harvesting potato tubers

Results

The results of variance analysis related to the traits measured in the experiment showed that the experimental treatments affected some of the studied traits. Plant height, shoot dry weight, tuber weight per plant, and plant performance were significantly affected by experimental treatments at a probability level of 1% (Table 1).

Table 1. Analysis variance (mean squares) of the studied traits in the experiment affected by the experimental treatments

S.O.V	**df**	**Height**	**Shoot dry weight**	**Tuber weight**	**Tuber number**	**Total yield**
Block	2	3.12 ^{ns}	16.50^{ns}	1611.41**	1.93 ^{ns}	272^{ns}
Treatment	7	45.62**	285.87**	29032.6	1.19 ^{ns}	6183410**
Error	14	1.10	9.00	174.2	0.92	59640
CV		6.65	13.88	16.33	19.85	10.49
S.O.V	df	Tuber 20 to 30 mm	Tuber 30 to 40 mm	Tuber 40 to 50 mm	Tuber 50 to 60 mm	Tuber More than 60 mm
Block	2	0.08 ^{ns}	0.05 ^{ns}	0.13 ^{ns}	0.08 ^{ns}	0.45^{ns}
Treatment	7	0.15 ^{ns}	0.020 ^{ns}	0.11 ^{ns}	0.12 ^{ns}	0.29^{ns}
Error	14	0.07	0.13	0.11	0.20	0.77
CV		42.62	55.15	47.30	35.65	36.07

** and * show significant differences in probability levels of 1 and 5%, respectively, ns: no significant difference

The results showed that the use of different foliar application treatments in the experiment was effective on plant height; therefore, potassium phosphate + potassium silicate + hydrogen peroxide treatment was able to significantly increase plant height compared to control and other experimental treatments. The highest plant height was observed in the treatment of potassium silicate + hydrogen peroxide + potassium phosphate and the plant height increased by more than 15% compared to the control treatment. After this treatment, potassium phosphate increased the plant height by 12% compared to the control. In general, the use of potassium phosphate, potassium silicate, potassium phosphate + potassium silicate, potassium phosphate + hydrogen peroxide, and potassium phosphate + potassium silicate + hydrogen peroxide treatments increased plant height compared to the control (Table 2). The use of potassium silicate as a foliar application in the plant increased the dry weight of the plant by 31% compared to the control. Also, hydrogen peroxide was able to increase the dry weight of the plant compared to the control by 27.52% (Table 2). Different treatments in the experiment affected the tuber weight in the plant. Potassium phosphate, potassium phosphate + potassium silicate, and potassium phosphate + potassium silicate + hydrogen peroxide treatments increased tuber weight in plants by 8.66, 11.41, and 14.17%, respectively, compared to the control. Other experimental treatments did not increase tuber weight in the plant and tuber weight in these treatments was lower than the control (Table 2). According to the results of this study, it was found that the performance of the total plant was affected by the experimental treatments. The use of potassium phosphate and also hydrogen peroxide increased the total plant performance by 18.27% and 18.47%, respectively, compared to the control (Table 2).

Table 2. The effect of different experimental treatments on plant height, dry weight, tuber weight, and total plant performance

Total yield	**Tuber weight (g/plant)**	**Shoot dry weight (g)**	**Height (cm)**	**Treatment**
Potassium phosphate	61.75 ab	66.09 bc	641.4 a	14600 a
Potassium silicate	58.03 cd	85.42 a	538.35 c	10450 e
Hydrogen peroxide	51.55 f	83.11 a	528.30 c	14625 a
Potassium phosphate + Potassium silicate	59.90 bc	68.69 bc	657.63 a	13850 b
Potassium phosphate + Hydrogen peroxide	57.87 d	63.73 c	655.84 e	13312.6 c
Potassium silicate + Hydrogen peroxide	54.91 e	56.67 d	382.61 d	12252 d
Potassium phosphate + Potassium silicate + Hydrogen peroxide	63.26 a	69.66 b	673.92 a	14100 b
Control	54.82 e	65.18	590.23 b	12344 d

Means followed by the same letter within each column are not significantly different at a probability level of 5% based on the LSD test.

Discussion

In this study, foliar application of plants with potassium-containing compounds had a great effect on improving plant growth Index. Growth improvement in potatoes due to potassium foliar application is likely owing to the role of potassium in plant nutrition, including accelerating the activity of enzymes and increasing the transfer of assimilates and protein synthesis. Potassium indirectly affects plant growth by increasing the rate of photosynthesis, assimilation of carbon dioxide, and assisting in the transport of carbon dioxide in biochemical pathways (Sangakkara *et al.*, 2000). Potassium is involved in many metabolic activities. This element has high mobility in plants and is most abundant in the cytoplasm. It also has a great effect on the osmotic potential of cells and tissues with its accompanying anions. Potassium is not metabolized but forms weakly changeable complexes (Marschner, 2002). Potassium ions are required to stimulate the activity of plasmalemma ATPase, which is involved in producing the necessary conditions for metabolites such as sucrose and amino acids (Barker and Pilbeam, 2007). Potassium plays an important role in regulating cellular inflammation with guard cells or stomata during stomatal movements. This element is one of the important nutrients for meristem cell growth and physiological activities such as regulation of water and gas changes in plants, protein synthesis, enzyme activity, carbohydrate transfer, and photosynthetic products (Marchner, 2012) Balancing pH and increasing Enzyme activity in plants (Ibrahim *et al.*, 2015). In other studies, the use of potassium in the potato plant increased the dry weight of shoots, leaf area, and accumulation of dry matter (Cao and Tibbitts, 1991). The positive effect of potassium silicate on shoot dry weight in plants may be due to the physiological activities of silicon, which is based on the relationship between silicon sediment at specific points and increased resistance in plants (Shaaban and Abou El- Nour, 2014). Foliar application of potassium silicate on the leaves may be more beneficial due to the silicon sediment in key areas that maintain the health of plant roots and are effective in improving water, macro, and micronutrients absorption (Shaaban and Abou El- Nour, 2014). Considering the improvement of plant growth conditions and increase in nutrient absorption, plant vegetative growth is improved and plant height is also increased. It seems that increasing the hydraulic conductivity of the roots in the plant causes the positive effects of silicon. Also, silicon as a messenger increases the antioxidant defense in the plant and then reduces the oxidative substances in the plant as a result, oxidative stress in the plant is reduced (Gong *et al.*, 2005, 2008). It also improves plant photosynthesis rate (Pilon *et al.*, 2013) and carboxylase activity (Gong and Chen, 2012) under dehydration conditions. Researchers have stated that the use of silicon in potatoes has improved the leaf area in the plant (Pilon *et al.*, 2013). In water scarcity conditions in the wheat, foliar application of this substance improved plant growth parameters and the concentration of color pigments (Maghsoudi *et al.*, 2015). Silicone prevents dehydration in the plant by preventing oxidative damage to the membrane (Ahmad and Haddad, 2011). In this study, foliar application of potassium phosphate increased plant height compared to control. It is possible that the effect of phosphorus on stimulating the growth of plant cells, and also the synthesis of ATP and various amino acids, increased vegetative growth in the plant, followed by photosynthetic products in the plant (Arun, 2002). Due to the foliar application of potassium phosphate and the presence of enough phosphorus, photosynthetic products and carbohydrates are produced in sufficient quantities in the plant and the necessary nutrients are provided for the plant shoots. Also, considering sufficient phosphorus in the plant, root growth and development are done to an acceptable level, and then the absorption of water and nutrients in the soil is well done, which ultimately increases performance (McArthur and Knowles, 1993; Wishart *et al.*, 2013). Performance improvement after phosphorus use has been reported by Maier et al. (2002). The use of potassium silicate as a foliar application at a concentration of 2000 ppm significantly increased tuber performance in the plant. The positive effects of potassium silicate in the plant are attributed to the improvement of vegetative parameters, an increase in nitrogen, phosphorus, potassium, and calcium, and an increase in free amino acids, soluble carbohydrates, and protein (Abd El-Gawad *et al.*, 2017). In a study, increased tuber performance and dry matter in the tuber have been reported to be related to the use of potassium silicate in the potato plant (Gong et al., 2011). Foliar application of potato plants with mineral elements accelerates plant growth and increases tuber performance (Allison et al., 2001; Trehan and Sharma, 2003; White et al., 2005). Adequate sources of phosphorus in the plant, produce carbohydrates and photosynthetic substances in desirable amounts; as a result, sufficient dry matter is stored in the plant (McArthur and Knowles, 1993). In addition, the transfer of photosynthetic material in the plant to the root increases under the presence of sufficient phosphorus, which results in increased performance in the plant (Wittenmayer and Marbach, 2005). In potatoes, sufficient phosphorus in the plant increases root length and stolon, which leads to an increase in the number of tubers and performance (Wishart et al., 2013). The positive effect of phosphorus uses in potato plants has been proven by other researchers (Fleischer *et al.*, 2012). The use of hydrogen peroxide increases root activity in water and nutrient absorption (Deng *et al.*, 2012). The positive effect of hydrogen peroxide on plant dry weight is most likely due to its positive effect on plant growth and development. Researchers have shown that hydrogen peroxide plays an important role in plant development and growth and plays a significant role in plant physiological activities. This compound is effective in plant growth by affecting the activity of sucrose phosphate synthase. This enzyme is involved in the conversion of triose phosphate to sucrose (Uchida *et al.*, 2002). In addition, foliar application of hydrogen peroxide in the plant also increases the root's uptake of minerals, which is associated with increased development of the root system in the plant (Nurnaeimah *et al.*, 2017). At low concentrations, hydrogen peroxide increases cell division in the plant (Hameed *et al.*, 2004). It has been shown that hydrogen peroxide as a signaling molecule has a great impact on plant growth (Khan *et al.*, 2018). This substance affects the amount of chlorophyll in the plant and due to its stressful role, increases the amount of chlorophyll in the plant (Liao *et al.*, 2012). In addition, hydrogen peroxide increases photosynthesis rate, stomatal opening, carbon dioxide concentration, and photosynthetic pigments in leaves (Li *et al.*, 2007), which can increase plant performance. It is also effective in many physiological activities such as stomatal cell movement, photosynthesis, light respiration, aging and cell cycle, and also biochemical responses during the plant growth process (Deng *et al.*, 2012).

Conclusion

According to the experimental results, it was found that foliar application of potato plants using different chemical compounds improved growth traits. The results showed that the combined use of potassium silicate + hydrogen peroxide + potassium phosphate in most of the studied traits had the greatest effect on the plant. The results showed that the use of potassium silicate + hydrogen peroxide + potassium phosphate as foliar application caused the highest height in the plant. In addition, it was found that foliar application of the plant with potassium silicate recorded the highest dry weight in the potato plant. Also, the use of potassium phosphate alone and in combination with potassium silicate and also foliar application of potassium silicate + hydrogen peroxide + potassium phosphate in the experiment could significantly increase tuber weight in the plant. Finally, the plant performance was the highest in the condition of foliar application of potassium phosphate and hydrogen peroxide separately. In general, it can be said that the combined use of potassium silicate + potassium phosphate and hydrogen peroxide, and also a foliar application with potassium phosphate alone in the potato plant is recommended to improve the growth traits in the plant.

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