International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 15, No. 6, p. 354-362, 2019

INNSPUB

RESEARCH PAPER OPEN ACCESS

Comparative effectiveness of different levels of NPK and potassium humate on leaf mineral content of potato (*Solanum tuberosum* L.)

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Key words: Leaves mineral content, Macronutrients, Potassium humate, Potato.

http://dx.doi.org/10.12692/ijb/15.6.354-362 Article published on December 29, 2019

Abstract

Poor soil organic content is one of the major causes of low uptake of mineral nutrients in the plants. Besides optimum use of inorganic fertilizers, it is a need of time to introduce organic fertilizers in combination with mineral fertilizers. Humate substances are one of such beneficial substances that can improve the uptake of mineral nutrients in the plants. Therefore, a current field study was conducted to assess the improvement of mineral uptake in the potato leaves via application of different levels of NPK fertilizers i.e. 0, 50, 75 and 100% recommended dose and potassium humate (K-humate) i.e. 0, 8, 12 and 16 kg ha^{-1}. It was observed that leaf mineral contents including N, P, K, Mg and Ca were positively affected by 100% recommended dose of NPK. In addition to above, application of 16 kg ha^{-1} K-humate also enhanced the uptake of N, P, K, Ca and Mg during the vegetative growth and their maximum concentrations were found at 85 days after planting. On the basis of results, it is concluded that K humate application is the necessity of time along with 100% recommended dose of NPK fertilizer for optimum uptake of nutrients in plants.

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Introduction

Plants require a large number of mineral nutrients which are taken up from soil solution by the roots. Edaphic nutrient deficiency or harmful excess in the soil constrain productivity of the crop (Vitousek *et al.*, 2010). Sources of nutrients are generally divided as inorganic, organic and biological. Use of inorganic fertilizers alone causes problems for human health as well as the environment (Mahmoud *et al.*, 2017). It needs to integrate both organic and organic fertilizers to achieve better crop growth (Nazik and Raed, 2017). Plants use inorganic minerals that are absorbed by roots as ions present in soil solution. Many factors affect nutrient uptake and their concentration in sap (Morris *et al.,* 2007). Analysis of many plant species led to an interaction between soil composition and leaf mineral contents at a genetic level (Anderson *et al.*, 2016).

Among mineral nutrients, phosphorus (P) is a major crop nutrient. It is essential for crop growth, photosynthesis, respiration, energy storage and cell division. It moves through roots by diffusion. Mostly young seedlings are usually very sensitive to P deficiency (Roy *et al.,* 2006). Similarly, potassium (K) is also an important nutrient for better growth and yield, especially for potato. It is involved in many metabolic processes that played an imperative role in the improvement of yield (Al-Moshileh *et al.*, 2005). However, inefficient application of fertilizers, less judicious use of agro-chemicals, conventional methods of seed sowing, poor management practices and low organic matter are major contributors of low yield of crops (Hussain *et al.*, 2011). So, there is a need to apply organic amendments for better intake of nutrients (Marinari *et al.*, 2000).

Among such organic sources, humic substances are dark brown with high cation exchange capacity and are considered very efficacious towards the improvement of soil fertility especially in organic matter deficient soils (MacCarthy, 2003). Humates include widespread decomposed organic matter of animal and plant residues. It contains macronutrient i.e., N, P and K as well as micronutrients (Cu, Mo, Zn and Mg). In addition to the above application of humate significantly increased soil water holding capacity and increases the plant's ability to withstand diseases and diseases (Russo and Berlyn, 1990). Furthermore, the positive effects of humic substances are also documented regarding the significant increase in the uptake of macronutrients (Delfine *et al.*, 2005). High ability of chelation of humates plays an imperative role in metal sorption and their uptake in the plants (Jones *et al.*, 2007).

That's why the current study was conducted with the aim to explore the combined effect of NPK mineral fertilizers and K-humate on soil and potato leaves mineral concentration. It is hypothesized that combined use of potassium humate and NPK fertilizer is a better approach for the improvement in nutrients concentration of potato leaves.

Materials and methods

Site of the experiment

The current experiment was conducted on potato (*Solanum tuberosum* L.) cv. Cardinal at research area of Department of Horticulture, Bahauddin Zakariya University Multan. Samples of soil were collected for the analyses of pre experimentation soil physio-chemical characteristics. Soil pH was analyzed by making mixing soil and deionized water in 1:10 ratio on digital pH meter (CD 640, Rigal Bennett, UK). For soil electrical conductivity (EC), extract from soil was collected and run on conductivity meter (model CM-180, ELICO). Organic matter was determined as per methodology of Ryan *et al.* (2001). Physio-chemical characteristics of soil was clayey loam in texture (sand 33.2%, silt 28.5% and clay 38.3%), EC=2.01 dSm^{-1}, pH=8.0, organic matter=0.84%, available P=17.94 µg g^{-1} and available K=240 µg g^{-1}.

Treatments plan

There were four levels of NPK fertilizers recommended dose i.e., 0, 50, 75 and 100% and K-humate i.e., 0, 8, 12 and 16 kg ha^{-1} with three replicates. The experiments were set up in a randomized complete block design with factorial arrangements.

Recommended fertilizer rates and application

The recommended dose of inorganic fertilizers for potato crop in the region is N = 120, P_2O_5 = 80 and K_2O = 80 kg ha^{-1}. A full dose of P_2O_5 and K_2O were applied at the time of seedbed preparation. K-humate and N were applied in three splits i.e., seedbed preparation, 30 and 75 days of plantation.

Sowing and seed rate

Potato seed tubers (1000 kg ac^{-1}) were sown in 2nd week of January for spring crops. The ridge – ridge space was 2 feet while plant-plant distance was 1 feet.

Harvesting

The crop was harvested in the last week of April. Sample of leaves were collected at 40, 85 and at the time of maturity harvest for the analyses of mineral nutrients.

Determination of N in leaves

Leaves were collected after 40, 85 days and at the time of harvesting for mineral analyses. The samples were digested by using H_2SO_4 and digestion mixture K_2SO_4 + $CuSO_4$=9:1 at 450 °C for 2 h. Finally, leaves N content was determined by distillation of samples at Kjeldahl's method (Bremner, 1965).

Determination of P, K, Ca and Mg in leaves

For analyses of P, K, Ca, Mg and Na, di-acid digestion was done. In digested samples, P was analyzed on spectrophotometer (Jones *et al.*, 1991).

Concentrations of K in the digests were analyzed on flame photometer (Jenway, PEP-7, Dunmow, UK). However, Ca and Mg were estimated by using atomic absorption spectrophotometer (AAS 5EA, Analytik Jena).

Statistical analysis

Collected data were statistically analyzed using the standard statistical procedure (Steel *et al.*, 1997). For assessment of treatments significance at 5% level of probability 2-factorial ANOVA was applied by using Statistix 8.1 software. LSD test was applied for differentiation among treatments.

Results

Nitrogen content

Results showed that the application of various levels of NPK fertilizer and K-humate did not significantly affect N content in potato leaves at 40 days. Application of 100% NPK recommended dose in combination with 16 kg ha^{-1} K humate remained significantly best for improving N content of potato leaves after 85 days as compared to all other treatments. It was noted that both 12 and 16 Kg ha^{-1} K-humate levels remained statistically alike but differed significantly as compared to 50 and 0 Kg ha^{-1} K-humates doses for improvement in N content of potato leaves at the time of harvesting (Fig. 1).

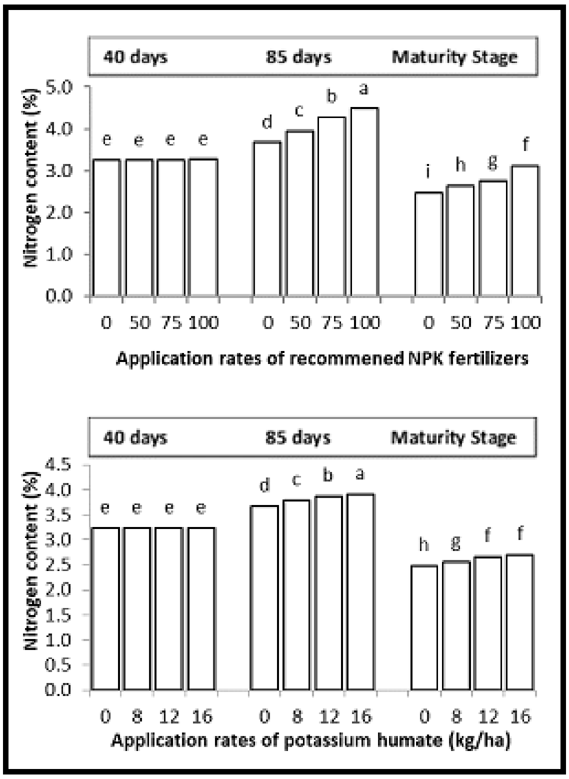

Fig. 1. Effect of various application rates of NPK fertilizers and potassium humate on the nitrogen content of potato leaves.

However, 100% NPK of recommended dose differed significantly as compared to 75, 50 and 0% NPK recommended doses for improvement in N content of leaves. The maximum increase 14.8% in N content of potato leaves at 85 days was observed where 100% NPK recommended dose was applied followed by 16 kg ha^{-1} K humate were applied (8.33%) as compared to control.

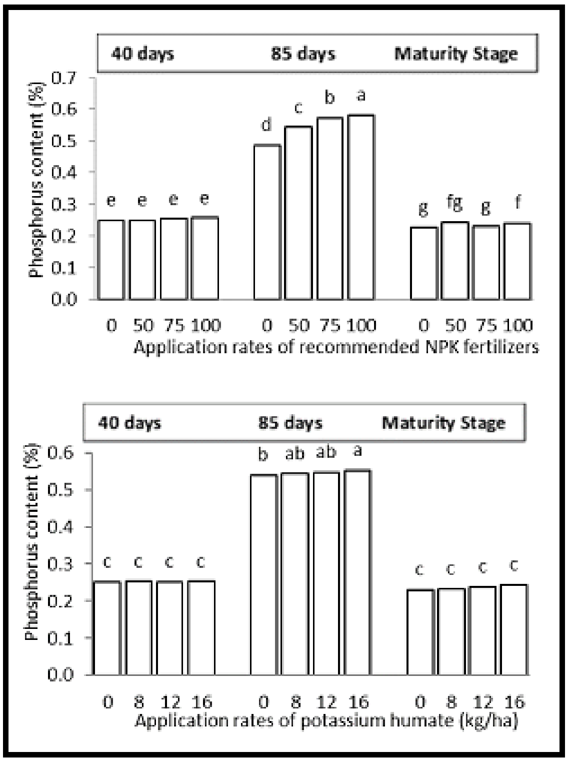

Fig. 2. Effect of various application rates of NPK fertilizers and potassium humate on phosphorus content of potato leaves.

Phosphorus content

Application of various levels of NPK fertilizer and K-humate did not differ significantly for P content in potato leaves at 40 days. It was observed that the addition of 100% NPK recommended dose was significant for improvement in P content of potato leaves after 85 days as compared to all other treatments. However, application of 8, 12 and16 kg ha^{-1} K humate remained non-significant while 16 kg ha^{-1} K humate differed significantly as compared to 0 kg ha^{-1} K humate for P content in potato leaves at 85 days. No significant change was noted in P content of potato leaves at the time of harvesting where various levels of K-humate were applied (Fig. 2).

However, 100% NPK recommended dose produced significant results as compared to 75 and 0% NPK recommended dose for improvement in P content of leaves at the time of harvesting. The maximum increase 20.8% in P content of potato leaves was observed where 100% NPK recommended dose was applied followed by 3.77% where 16 kg ha^{-1} K humate was applied at 85 days as compared to control.

Potassium content

Addition of various levels of NPK fertilizer dose differed significantly in improving K content in potato leaves at 40 days but various levels of K-humate remained non-significant. It was observed that the addition of 100% NPK recommended dose significantly increased the K content of potato leaves after 85 days as compared to all other treatments. However, the addition of 12 and 16 kg ha^{-1} K humate remained statistically alike but differed significantly from 0 and 8 kg ha^{-1} K humate levels at 85 days for K content in potato leaves (Fig. 3).

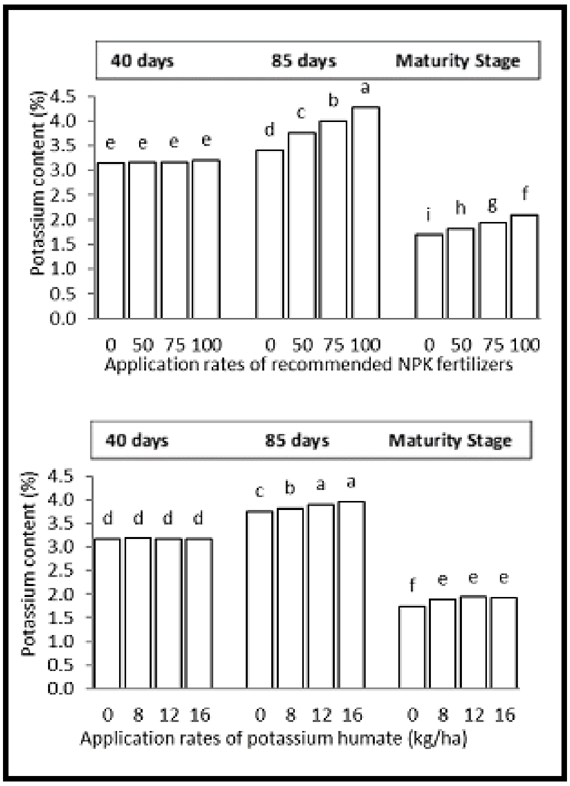

Fig. 3. Effect of various application rates of NPK fertilizers and potassium humate on potassium content of potato leaves.

No significant change was noted in K content of potato leaves at the time of harvesting where various levels of K-humate were applied except control. However, 100% NPK recommended dose differed significantly as compared to 75, 50 and 0% NPK recommended dose for improving K content of leaves at the time of harvesting. The maximum increase of 20.3% in K content of potato leaves was observed where 100% NPK recommended dose was applied followed by 5.33% where 16 kg ha^{-1} K humate were applied at 85 days of the plantation.

Calcium content

Application of various levels of NPK fertilizer and K-humate did not differ significantly for Ca content in potato leaves at 40 days. It was observed that the addition of 100% NPK recommended dose remained significant for improvement in Ca content of potato leaves after 85 days. However, application of 0, 8, 12 and16 kg ha^{-1} K - humate doses remained statistically alike at 85 days for Ca content in potato leaves. No significant change was noted in Ca content of potato leaves at the time of harvesting where various levels of K-humate were applied (Fig. 4).

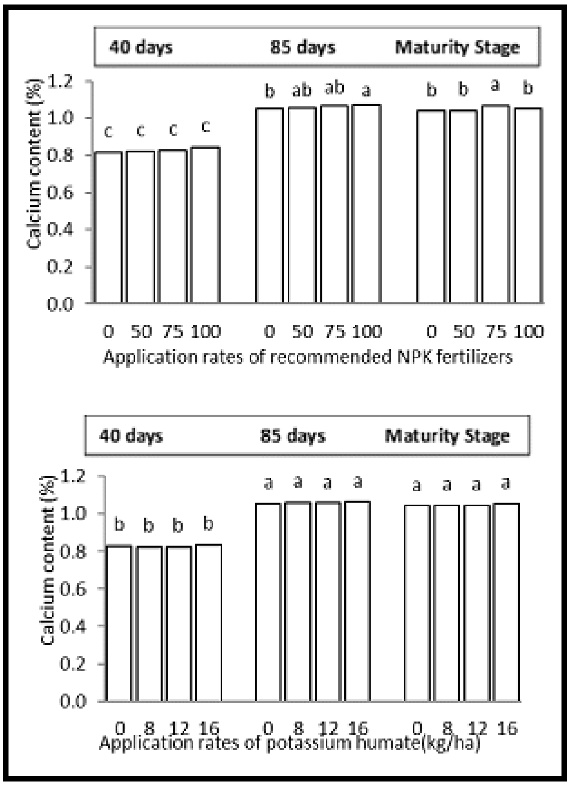

Fig. 4. Effect of various application rates of NPK fertilizers and potassium humate on the calcium content of potato leaves

However, 75% NPK recommended dose differed significantly as compared to 100, 50 and 0% NPK recommended doses for the improvement in Ca content of leaves at the time of harvesting. The maximum increase 1.87% in Ca content of potato leaves was observed where 100% NPK recommended dose was applied at 85 days as compared to control.

Magnesium content

Addition of various levels of NPK fertilizer and K-humate remained non-significant for Mg content in potato leaves at 40 days. It was noted that the addition of 75 and 100% NPK recommended doses remained significantly better for improvement in Mg content of potato leaves after 85 days as compared 50 and 0% NPK recommended doses. However, the addition of 8, 12 and16 kg ha^{-1} K - humate doses remained statistically alike but differed significantly as compared to 0 kg ha^{-1} K humate at 85 days for Mg content in potato leaves. No significant change was noted in K content of potato leaves at the time of harvesting where various levels of K-humate were applied except control (Fig. 5). However, 75% NPK recommended dose differed significantly better as compared to 100, 50 and 0% NPK recommended doses for improvement in Mg content of leaves at the time of harvesting. The maximum increase 5.95% in Mg content of potato leaves was observed where 100% NPK recommended dose was applied followed by 16 kg ha^{-1} K humate (3.52%) at 85 days over control.

Discussion

In the present investigation, leaves N, P, K, Ca and Mg were significantly enhanced where 100% of NPK recommended dose and 16 kg ha^{-1} K-humate were applied. This increase in concentrations of N, P, K and Mg in leaves was noted till 90 days of planting, later it decreased and the lowest amounts of these mineral nutrients were observed at harvest. According to Awad (2005), the better availability of NPK via their optimum application plays a vital role in the improvement of mineral contents of crop leaves. The results of the current study are in agreement with Kamel *et al.* (2008). They argued that increasing NPK levels significantly enhanced nutrients content. Similar kind of result was also documented by Rohily *et al.* (2010) where improvement in minerals uptake resulted in better yield of the potato crop. A significant increase in leaves phosphorus content of lettuce has been recorded with the application of phosphorus (Cimrin and Yilmaz, 2005). Application of K-humate also significantly improved leaf N, P, K and Mg contents at 85 days of planting and also at harvest. This increase in mineral content may be due to enhancing the effect of K- humate on the absorption and translocation of these minerals. It may also be due to its effect on increasing plant metabolism (Zaghloul *et al.,* 2009).

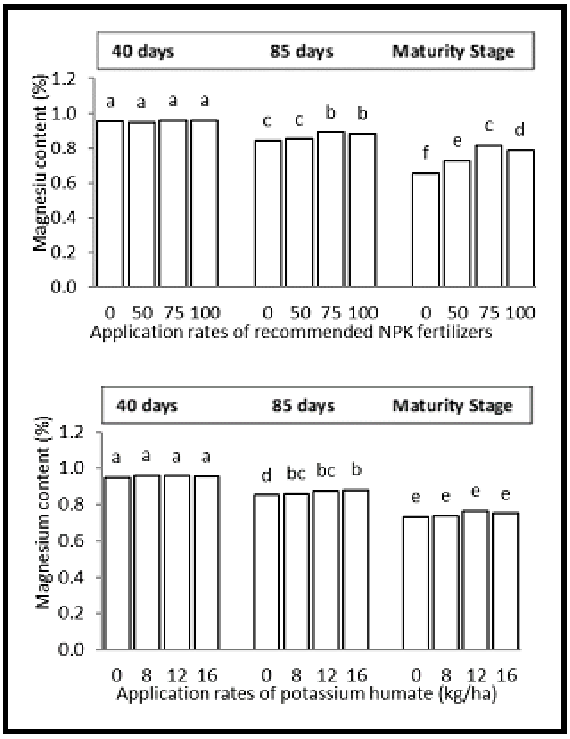

Fig. 5. Effect of various application rates of NPK fertilizers and potassium humate on magnesium content of potato leaves.

Higher chelating ability of humate ions might be one of the major cause of improvement in mineral nutrients of potato leaves in the current experiment. Further, humic substances are also involved in the regulation of nitrogen uptake via stimulation of plasma membrane H^+-ATPase activity (Canellas *et al*., 2002). Celik *et al.* (2008) observed that under calcareous soil conditions, application of humic substances in soil improved the intake of N, K, and Mg in maize plant. According to Wang *et al.* (1995), humic acids addition with P fertilizer enhanced water-soluble phosphate and its uptake which can cause 25% improvement in yield. Slow-release of K due to humate-potassium complex formation in soil, played an imperative role in the enchantment of K uptake in the plants (Reddy *et al*., 2004). The higher application rate of K-humate also contributes to the release of K in the soil solution where it becomes readily available for the plants (Sivakumar and Devarajan, 2005). In addition to above, better root development and their elongation increase due to addition of humate enhance the surface area of plants roots for the absorption of mineral nutrients in the soil (Eyheraguib *et al*., 2004). Patil *et al.* (2011) also observed similar kind of benefits when they applied K. humate, especially in *Glycine max*, *Phaseolus mungo* and *Triticum aestivum*.

Conclusion

It is concluded that the application of a recommended dose of fertilizer is important for improvement in the uptake of mineral nutrients in the leaves of potato. Application of K-humate also played an imperative role in better uptake of mineral nutrients in potato. However, more investigations are suggested to check the best application rate of K-humate in combination with recommended fertilizer in different crops.

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