



Short Communication

The effect of foliar application of urea, humic acid and micronutrients on potato crop

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ABSTRACT- The influence of foliar application of urea, humic acid (HA), Zinc (Zn), and Boron (B) on potato yield (CV. Cror) was studied in a field experiment during 2010-2012 at the research farm of Nuclear Institute for Food and Agriculture (NIFA). Treatments consisted of i) Control, ii) Nitrogen-Phosphorous-potassium (NPK) (250,150,250 kg ha⁻¹), iii) NPK (125,75,125 kg ha⁻¹) with 0.03% HA, iv) NPK (125,75,125 kg ha⁻¹) with 0.5% urea, v) NPK (125,75,125 kg ha⁻¹) with 5 kg ha⁻¹ Zn, vi) NPK (125,75,125 kg ha⁻¹) with 1 kg ha⁻¹ B, vii) NPK (125,75,125 kg ha⁻¹) with 5 kg ha⁻¹ Zn and 1 kg ha⁻¹ B, viii) NPK (125,75,125 kg ha⁻¹) with 5 kg ha⁻¹ Zn, 1 kg ha⁻¹ B and 0.03% HA. Urea, Zn, HA, and B were sprayed at vegetative, flowering, tuber formation and ripening growth stages. Among all the mentioned treatments, maximum tuber yield was obtained in the treatment receiving half NPK (soil applied) and H.A 0.03% (foliar applied). Maximum N and P content in potato tubers were also found in the same treatment. Results showed that half NPK (soil applied) + foliar application of HA (0.03%) are economical and beneficial for the farmers of the area.

INTRODUCTION

Potato is the main vegetable crop in irrigated areas of Pakistan. It is the fourth most important crop by its volume of production; having high nutritive value and giving high returns to the farmers. Potato is an important source of carbohydrates, protein, essential minerals and vitamins. The total potato crop area in Pakistan is 137.7 thousand hectare with the production rate of 2554.2 thousand tones while average yield is 22.7 tones ha⁻¹. The total potato crop production in Khyber Pakhtunkhwa is 123 thousand tones grown in 9.2 thousand hectares (MINFAL 2010-11). Nevertheless, Pakistan has still a lower rank in potato production as compared to other countries like Netherlands, France, Germany and the USA, and the main reason behind this issue is low soil fertility of this country.

Micronutrients such as iron (Fe), manganese (Mn), copper (Cu), zinc (Zn) and boron (B) play a significant role in plant development. Among micronutrients, boron (B) and zinc (Zn) have a pivotal role in pollination and seed set processes so that their inadequacy can cause a decrease in seed formation which leads to subsequent yield reduction. Zinc plays a key role in hormone biosynthesis, structural stability of organelles, cytochrome c synthesis, activation and proper function

of a number of enzymes, protein synthesis, stability and integrity of the root cell plasma membrane. Boron is involved in carbohydrates metabolism and is necessary for protein synthesis. It is essential for pollen germination and seed and cell wall formation too. Boron is also associated with water and nutrients transportation from root to shoot (Ziaeyan et al., 2009). Humic substances have also a major contribution in soil fertility maintenance and plant nutrition (Bryan and Stark, 2003; Mikkelsen, 2005). The cultivated soils of Pakistan are generally deficient in essential plant nutrients (Idris et al., 2001). Due to the interactions of many factors, the modern crop fertility concept is a very complex process. In order to improve vegetable production and nutrients efficiency, a proper nutrient management system is required involving organic sources, biofertilizers and micronutrients. The high cost of fertilizers has increased the production expenses so that the farmers are using imbalance fertilizers, which results in lower nutrients uptake and then lower quality of plants. Literature reveals that humic acid and micronutrient foliar application increased the yield and quality of vegetable crops. It is also reported that plants grown on soils containing adequate humic and fulvic acids are less

subject to stress and are healthier and produce higher yields (Sarir et al., 2006, Rizk et al., 2010).

Fertilization as foliar application is considered the most important agricultural practice which affects the growing period of plant foliage and tuber formation as well as the quality of produced yield (Gabr et al., 2001; Bekhit et al., 2005). The micronutrients' deficiencies decrease the quality and yield of the crops and act as catalyst in the uptake and use of many macronutrients. The researchers recommend the foliar application of fertilizers in vegetable and fruit crops that contain various essential macro and micronutrients compared to soil applications. Foliar nutrient sprays can be effective in treating existing or developing nutrient deficiencies and usually produce a quicker response than soil applications. This is particularly true for elements such as iron, zinc, manganese, copper and boron. The application of foliar fertilizers is the quickest method to deliver nutrients to the tissues and organs of the crop.

The objective of this study was to evaluate the impacts of urea, humic acid, zinc and boron applied alone and in combination with full and half recommended dose of NPK on the yield and nutrient uptake of potato crop.

MATERIALS AND METHODS

Field experiments were conducted during 2010-2012 on the same piece of land at research farm of NIFA to study the influence of foliar application of some nutrients and NPK fertilizers on potato crop. Treatments consisted of urea, humic acid (HA), Zn and B which were applied alone and in combination with (125, 75,125) NPK. Zn and B were applied as zinc sulphate and borax was applied at the rate of 5 and 1 kg ha⁻¹ respectively. Urea solution (0.5%) and humic acid 0.03% were applied as foliar application. Humic acid and other nutrients were sprayed at vegetative, flowering, tuber formation and ripening growth stages. Phosphorus (P) and Potassium (K) were applied at the time of sowing as single super phosphate and potassium sulphate respectively, while half of N (Urea) was applied at sowing time and half at earthing up. The experiment consists of eight treatments including control, full recommended dose of NPK (soil Applied), half recommended NPK (soil applied) with H.A (0.3%), half recommended NPK (soil applied) with urea (0.5%), half recommended NPK (soil applied) with Zn, half recommended NPK (soil applied) with B, half recommended NPK (soil applied) with Zn and B, half recommended NPK (soil applied) with Zn, B and H.A (0.3%) (Table. 1). Potato variety CV. Cror was sown in randomized complete block (RCB) design with three replications in plot measuring 4 x 4.8 m². The distance between rows was 80 cm. Potatoes were harvested at physiological maturity. Potato yield and tubers samples were analyzed for total Nitrogen, Phosphorus, Zinc and Boron contents.

Physicochemical properties of the experimental soil indicated that soil pH was 7.8, electrical conductivity (EC) 0.59 dS m⁻¹, organic matter 0.94%, total soil N 0.06% and (AB-DTPA) phosphorus (P) 4 mg kg⁻¹ zinc

(Zn) 0.5 mg kg⁻¹, Boron (B) 0.3 mg kg⁻¹ and soil texture was silty loam.

Yield data were recorded at the field at the time of harvesting. Tuber samples were ground in a Wiley mill. 0.5 gm portions of the dried material were digested in tri-acid mixture and P was determined by measuring the intensity of metavanadate yellow color using a spectrophotometer (Jackson, 1962). Zn in soil was determined by the AB-DTPA extraction procedure (Soltanpour and Schwab, 1977). Total Nitrogen was measured by the Kjeldahl method (Bremner and Mulvaney, 1982). Boron in soil was determined by method outlined by Binghaam (1982) and in plants by dry ashing method (Jackson, 1962)

Table 1. Treatments detail

Treatment	Nutrients Applied
T1	Control
T2	Soil application of (250,150,250 kg ha ⁻¹) NPK
T3	1/2 NPK (125, 75,125 kg ha ⁻¹) soil App + Humic acid .03 %
T4	1/2 NPK (125, 75,125 kg ha ⁻¹) soil App + urea 0.5%
T5	1/2 NPK (125, 75,125 kg ha ⁻¹) soil App + Zinc
T6	1/2 NPK (125, 75,125 kg ha ⁻¹) soil App + Boron
T7	1/2 NPK (125, 75,125 kg ha ⁻¹) soil App + Zinc+ Boron
T8	1/2NPK (125, 75,125 kg ha ⁻¹) soil App + Zn+ B+ H.A .03 %

Statistical Analysis

Data were analyzed statistically through the analysis of variance (ANOVA) following the method described by Gomez and Gomez (1984) using MSTATC computer software.

RESULTS AND DISCUSSION

The foliar application of micronutrients, holmic acid and urea combined with NPK had a significant effect on means of potato tuber yield (Table 2). Maximum potato tuber yield (17622 kg ha⁻¹) was obtained in T3 treatment followed by T4 treatment. Analysis of the data showed that different treatments had significant effects on N concentration in potato tubers. Significantly higher N (Table 2) content in potato tuber was obtained in T3 treatment followed by T8 treatment, while minimum N content in potato tuber was obtained in control treatments. During 2010-2011, maximum N content was found in T8 treatment while during 2011-2012, maximum N content was obtained in T3 treatment. Phosphorus content in potato tubers (Table 3) was maximum in T3 treatment followed by T8 treatment. During both years, the P content was maximum in T3 treatment application.

Table 2. Effects of foliar application of urea, Zn, B and Humic Acid Application on Yield and N, content in potato tubers during 2010-2012

Treatments	Yield kg ha^{-1} 2010-2011	Yield kg ha^{-1} 2011-2012	Mean of yield kg ha^{-1}	%N 2010-2011	% N 2011-2012	Mean of % N content
Control	10990 cd	15972 b	13481 c	0.94 d	0.896 e	0.918 e
NPK soil (full dose)	12431 bc	19931 ab	16181 ab	1.04 b	1.053 bc	1.05 bc
Half NPK+ H.A 0.03%	14444 ab	20799 a	17622 a	1.10 a	1.110 a	1.1050 a
Half NPK+ urea 0.5%	13663 abc	20660 ab	17161 a	1.04 b	1.070 b	1.05 bc
Half NPK+ Zn	13201 bc	20677 ab	16939 ab	1.02 bc	1.056 bc	1.04 bcd
Half NPK+ B	12899 bc	16215 ab	14557 bc	1.03 bc	1.030 cd	1.03 cd
Half NPK+ Zn+ B	13594 ab	17049 ab	15321 abc	1.00 c	1.013 d	1.01 d
Half NPK+ Zn+ B+0.03% HA	15208 a	17969 ab	16589 ab	1.11 a	1.023 cd	1.06 b
LSD _{0.05}	1806.9	4786.4	2520.3	0.0357	0.0353	0.0328

Table 3. Effects of foliar application of urea, Zn, B and Humic Acid Application on, P, Zn, and B content of potato tubers during 2010-2012

Treatments	% P 2010-11	%P 2011-12	Mean of % P	Zn (ppm) 2010-11	Zn (ppm) 2011-12	Mean of Zn (ppm)	B (ppm) 2010-11	B (ppm) 2011-12	Mean of B (ppm)
Control	0.2917 d	0.283 f	0.28 e	17.66 f	15.33 d	16.50 f	3.73 d	3.23 e	3.48 e
NPK soil (full dose)	0.4500 b	0.496 b	0.47 b	21.63 de	19.86 c	20.75 de	5.10 c	4.70 d	4.90 d
Half NPK+ H.A 0.03%	0.5833 a	0.616 a	0.60 a	25.00 bc	24.73 b	24.86 b	6.60 b	6.56 bc	6.58 ab
Half NPK+ urea 0.5%	0.3833 c	0.503 b	0.43 bc	21.20 de	19.33 c	20.26 de	6.46 b	5.90 c	6.18 c
Half NPK+ Zn	0.3667 c	0.420 cd	0.39 cd	28.56 a	27.23 a	27.90 a	6.13 b	6.16 c	6.15 c
Half NPK+ B	0.4167 bc	0.466 c	0.43 bcd	20.83 e	18.33 c	19.58 e	7.70 a	7.9 a	7.80 ab
Half NPK+ Zn+ B	0.3667 c	0.380 de	0.3733 d	23.53 cd	20.03 c	21.78 cd	7.63 a	7.36 ab	7.50 b
Half NPK+ Zn+ B+0.03% HA	0.5500 a	0.36 e	0.45 bc	26.60 ab	19.20 c	22.90 c	8.20 a	8.03 a	8.11 a
LSD _{0.05}	0.0596	0.0417	0.065	2.3834	1.820	1.87	0.8506	1.043	0.595

Higher Zn content in potato tuber was found in T5 treatment (Table 3) followed by T3 treatment. Results of both years showed that maximum Zinc content was found in the same T5 treatment.

Significantly higher boron content during both years (Table 3) was found in T8 treatment followed by T6 treatment. Potato tuber with lowest boron content was obtained in the control treatment. During both years 2010-2012, Boron contents were maximum in T8 followed by T6. Maximum value cost ratio in 2010-2012 (Table 4) was obtained in T3 treatment followed by T5 treatment. Results showed that, $\frac{1}{2}$ NPK (125, 75, 125 kg ha^{-1}) (soil applied) + foliar application of 0.03% humic acid improved the yield and was the most beneficial among all the treatments.

This study investigated the yield and nutrients contents of potato as affected by the foliar application of urea, zinc, boron and humic acid applied alone and in

combination. The highest potato tuber yield was obtained in the plots having humic acid compared with other treatments. The highest values were obtained by the foliar application of humic acid in both the years. These increases in total tuber yield may be due to the hormonal effect of humic acid that improve the nutrient status of plants. These results are in agreement with those reported by Verlinden et al., (2009), Selim et al., (2009) and Ezzat et al., (2009) who found that the application of humic substances to potato enhanced tuberous yield quantity and quality. Significant increases in potato tuber yield due to the foliar application of micronutrients Zn, B and humic acid confirm that foliar fertilizers are absorbed right at the site where they are used and are effective sources of traits, increased yield and better nutrient uptake by wheat crop under foliar fertilization of urea. Zinc content in potato tubers was maximum in the treatments

where Zn was applied alone or in combination with Boron and humic acid or alone with humic acid. Zinc uptake deserves special attention because our soils are deficient in zinc and are largely immobile. As a result of limited soil availability, zinc is applied as a foliar spray. Similarly, elevated boron content was seen where boron was applied in combination with humic acid. Foliar spray of humic acid on wheat and onion crops showed uptake, plant growth and yield.

(Delfine et al., 2005; Sangeetha et al., 2006). Our results are in agreement with Bajapai and Chauhan (2001) who reported that zinc, boron and manganese treatments significantly improved the performance of okra in terms of the number of fruits per plant, fresh and dry fruit weight, seed per fruit and seed weight. Naresh and Singh (2002) reported that zinc and boron significantly improved fruit set normal fruit, cracked fruits and fruit maturity in the treated plants over control in litchi plants. Mishra et al. (2003) also observed significant improvements in chlorophyll content and fresh weight of kinnow treated with zinc, iron and boron. The ultimate aim of fertilizer and nutrients application in different combinations to the crop is to paid to foliar spray of humic acid. plant nutrients applications. High N and P content were also observed in the treatments having foliar applied humic acid. Silberbush (2002) stated that foliar fertilization is a widely used practice to correct nutritional deficiencies in plants caused by improper supply of nutrients to roots. Foliar fertilization of crops has been considered a precious supplement to the application of nutrients under adverse soil and environmental situations, low soil nutrients bioavailability, hard top soil, and decreased root activity during the reproductive growth stage of plants (Naruka et al., 2000; Alkaff and Hassan, 2003). It facilitates

timely translocation of deficient nutrients to plant system through leaf tissues (Chattopadhyay et al., 2003; Fageria et al., 2009). Foliar fertilization not only improves plant growth traits, crop yields and nutrient uptake by crops (Maitlo et al., 2006) but also enhances nutrient use efficiency of crops (Fageria et al., 2009). Maitlo et al. (2006) reported enhanced growth boost up yielding ability of the crop in order to achieve highest yield return than the cost of fertilizer/ nutrients applied. Maximum net returns were obtained in the treatment where humic acid was applied as foliar. Maximum value cost ratio of (5.35) was obtained in treatment T3 where ½ NPK (soil applied) + 0.03% humic acid (foliar) were applied. Our results are in agreement with Abid et al., (2007) who observed the highest VCR of 8.9, when micronutrients were applied. It is obvious from the results that humic acid is economical and cost-effective.

CONCLUSIONS

In a sustainable or organic farming, the application of organic products can be a noteworthy alternative to chemicals fertilizers. Obtained results showed that humic acid is able to produce positive effects on the growth, quality and yield of potato. It can be concluded that the foliar application of 0.03% humic acid + ½ NPK (soil applied) gave prominent results. Furthermore, it is recommended that more attention should be paid to foliar spray of humic acid.

Table 4. Value cost ratio of the foliar application of Urea, Zn, B and Humic Acid Application on potato yield during 2010-2012

Treatments	Potato tuber yield Kgha ⁻¹	increase over Control Kgha ⁻¹	Net profit (Rs)	Cost of Fertilizer (Rs)	VCR
Control	13481	-	-	-	-
NPK soil (full dose)	16181	2700	54000	30913	1.75
half NPK+ H.A 0.03%	17622	4141	82820	15471	5.35
half NPK+ urea 0.5%	17161	3680	73600	15509	4.74
half NPK+ Zn	16939	3458	69160	16371	4.22
half NPK+ B	14557	1076	21520	15551	1.38
half NPK+ Zn+ B	15321	1840	36800	16465	2.23
half NPK+ Zn+ B+ H.A .03%	16589	3108	62160	16479	3.77

N @ Rs 45.65 kg⁻¹ P @ Rs 50 kg⁻¹ K @ Rs 48 kg⁻¹ Zn @ Rs 91.42 kg⁻¹ B @ Rs 94.11 kg⁻¹, 0.5% Urea @ Rs 52.5 ha⁻¹, H.A @ Rs 13.5 ha⁻¹, Potato @ Rs 20 kg⁻¹

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تأثیر محلول پاشی دوره، اسید هیومیک و عناصر غذایی کم مصرف بر محصول سیب زمینی

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بور

محلول پاشی

چکیده - تأثیر محلول پاشی اوره، اسید هیومیک، روی و بور بر عملکرد سیب زمینی در یک کشت مزرعه ای در سال های ۱۳۸۹ تا ۱۳۹۱ در مزرعه تحقیقاتی موسسه علوم هسته ای غذا و کشاورزی انجام شد. تیمارها شامل: (۱) شاهد، (۲) نیتروژن، فسفر، پتاسیم (۲۵۰، ۱۵۰، ۲۵۰ کیلوگرم در هکتار)، (۳) نیتروژن، فسفر، پتاسیم (۱۲۵، ۷۵، ۱۲۵ کیلوگرم در هکتار) با ۰/۰۳ درصد اسید هیومیک، (۴) نیتروژن، فسفر، پتاسیم (۱۲۵، ۷۵، ۱۲۵ کیلوگرم در هکتار) با ۰/۵ درصد اوره، (۵) نیتروژن، فسفر، پتاسیم (۱۲۵، ۷۵، ۱۲۵ کیلوگرم در هکتار) ۵ کیلو گرم در هکتار روی، (۶) نیتروژن، فسفر، پتاسیم (۱۲۵، ۷۵، ۱۲۵ کیلوگرم در هکتار) با یک کیلوگرم در هکتار بور، (۷) نیتروژن، فسفر، پتاسیم (۱۲۵، ۷۵، ۱۲۵ کیلوگرم در هکتار) با ۵ کیلوگرم در هکتار روی و یک کیلوگرم در هکتار بور، (۸) نیتروژن، فسفر، پتاسیم (۱۲۵، ۷۵، ۱۲۵ کیلوگرم در هکتار) با یک کیلوگرم در هکتار روی و یک کیلوگرم در هکتار بور و ۰/۰۳ درصد اسید هیومیک. اوره، روی، اسید هیومیک و بور در مراحل مختلف رویشی، گلدهی، تشکیل غده و رسیدن گیاه بر روی گیاهان پاشیده شدند. در میان تیمارهای به کار رفته، بیشترین عملکرد غده در تیمار نصف نیتروژن، فسفر و پتاسیم (کاربرد خاکی) و ۰/۰۳ درصد اسید هیومیک (محلول پاشی) به دست آمد. بیشترین مقدار نیتروژن و فسفر در غده سیب زمینی نیز در همین تیمار مشاهده شد. نتایج نشان داد که نصف نیتروژن، فسفر و پتاسیم (به صورت کاربرد خاکی) و محلول پاشی اسید هیومیک (۰/۰۳ درصد) برای کشاورزان منطقه مورد مطالعه اقتصادی و سودمند می باشد.