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Response of stevia to foliar application of prilled urea

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Abstract

Urea can be supplied to plants through the foliage, facilitating optimal N management, which minimizes N losses to the environment. The efficiency of N assimilation through foliage depends upon several factors including N levels and varieties or genotypes. No information is available on the effect of the foliar application of urea on stevia (*Stevia rebaudiana*, Bertoni). The objective of the study was to evaluate the effect of foliar application of prilled urea applied in different concentrations on the growth, yield components, leaf biomass yield, N content and its uptake by stevia. Seven levels of urea viz. 0.0, 0.5, 1.0, 1.5, 2.0, 2.5 and 3g $2L^{-1}$ were sprayed 10 days after planting (DAP) in acid and non-calcareous soils at an interval of one week up to 60 DAP. Foliar urea application significantly increased plant height, branch and leaf number, leaf area, fresh and dry leaf weight, leaf N content and uptake by stevia. Most of the parameters were increased with the advancement of growth period from 30 to 60 DAP. The foliar spray of 2.0g urea solution was found to be most effective for enhancing the growth, leaf yield and yield attributes of stevia. The yield increase was 478% in acid soil and 485% in non-calcareous soil over control. Further increase in the concentrations of urea spray (2.5 and 3.0g) was not found to be useful as it declined the leaf yield by 135% in acid and 175% in non-calcareous soil probably due to its toxicity. N content in stevia leaves was significantly increased with the increased levels of urea up to 3.0g in both soils. Conversely, the trend of N uptake did not follow the trend of N contents of stevia leaves. N uptake as expected increased as foliar application of urea increased up to 2.0g and then decreased with further addition. The results suggest that farmers can be advised to apply prilled urea as foliar spray @ 1g L^{-1} for higher leaf biomass yield and N uptake by stevia either in acid or non-calcareous soils under the agro-climatic conditions of Bangladesh Agricultural University, Mymensingh.

Keywords: Stevia, Prilled urea, Foliar application, Leaf yield, N uptake

Introduction

The role of macro and micro nutrients is crucial in crop nutrition for achieving higher yields (Raun & Johnson, 1999). The soils of Bangladesh are deficient in nitrogen (N) and are supplemented with chemical fertilizer for enhancing the crop productivity. Nitrogenous fertilizers play a vital role in modern farm technology though only 20-50% of the soil applied N is recovered by the annual crops (Bajwa, 1992). Both excess and insufficient N applications may cause either yield reduction or some physiological disorders. The partial and in-efficient use of N results in lower crop harvests. The left over N is lost from the soil system through denitrification, volatilization and leaching.

Foliar fertilization, that is nutrient supplementation through leaves, is an efficient technique of fertilization which enhances the availability of nutrients. It has been observed that utilization of fertilizers especially urea applied through soil is not as effective as when it is supplied to the plant through foliage along with soil application (Mosluh *et al*., 1978). The interest in foliar fertilizers arose due to the multiple advantages of foliar application methods such as rapid and efficient response to the plant needs, less product needed, and independence of soil conditions. A high penetration rate is one of the pre-requisites for efficient foliar nutrition. Urea, due to its intrinsic characteristics such as small molecular size, non-ionic nature and high solubility, is usually taken up rapidly through the leaf cuticle.

Urea can be supplied to plants through the foliage, facilitating optimal N management, which minimizes its losses to the environment. Most plants absorb foliar applied urea rapidly and hydrolyze the urea in the cytosol (Witte *et al*. 2002). The beneficial effects expressed as an increase in yield and an improvement of crop quality were reported in many vegetable species such as cabbage, onion, cucumber, squash (Padem and Yildirim 1996, Kolota and Osinska 2001). The absorption rate of mineral nutrients by aboveground plant parts considerably differs not only among plant species but also among varieties within the same species (Wojcik 2004). The efficiency of N assimilation through foliage, however, depends upon several factors including varieties or genotypes. No information is available on the effect of the foliar application of urea on stevia. Therefore, the study under report was initiated to investigate the effects of foliar application of urea on growth, yield components, leaf biomass yield, N content and uptake by stevia leaf.

Materials and Methods

A pot experiment was conducted at the net house of the Department of Agricultural Chemistry, Bangladesh Agricultural University, Mymensingh during March to May, 2012 to evaluate the effects of different levels of foliar application of urea on yield, yield components, N content and uptake by stevia. Two soils viz. acid and non-calcareous of contrasting physical and chemical properties were used (Table 1).

Table 1. Physical and chemical properties of acid and non calcareous soil used for the experiment

Soil properties	Acid soil	Non calcareous soil
Texture	Clay	Sandy clay loam
pH	5.10	6.70
EC (dS m^{-1})	0.25	0.67
OM (%)	1.56	1.80
Total N (%)	0.09	0.11
Available P (µg g^{-1}soil)	3.00	12.00
Exchangeable K (cmol kg^{-1}soil)	0.19	0.17
Available S (µg g^{-1}soil)	11.86	10.00

Approximately 40kg soils from each location (*Madhupur* for acid soil and *BAU farm* for non-calcareous soil) were collected from 0 -15cm depth of selected fellow land for the experiment. The samples were made free from plant residues and other extraneous materials, air dried, ground and sieved through a 2mm sieve. 500g sieved soil from each source was preserved in a polythene bag and the physical and chemical properties were analyzed following standard procedure (Page *et al.* 1982).

Eight kg processed soil was taken in each earthen pot of 23cm in height with 30cm diameter at top and 18cm at bottom leaving 3cm from the top. *In vitro* produced 45 day old stevia seedlings (S*tevia rebaudiana* Bertoni) were collected from *brac* biotechnology laboratory, Joydebpur, Gazipur and used for the experiment. One stevia seedling was planted in each pot during 1^{st} week of March, 2012. P, K, S, Zn and B were applied as basal doses @ 100, 200, 30, 3 and 1kg ha^{-1} from TSP, MoP, gypsum, zinc sulphate and boric acid, respectively. Foliar spray of prilled urea @ 0, 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0g $2L^{-1}$, respectively, were prepared using distilled water and applied at 7 day interval 10 days after planting (DAP) as per treatments. The controlled pot was sprayed only with distilled water. The experiment was laid out in completely randomized design with three replications. Total number of pots was 42 (7 treatment X 2 soil X 3 replication). Intercultural operations like irrigation, soil loosening, weeding, insect pest control, removal of flowers etc. were done as and when necessary. Data were collected at 15, 30, 45 and 60 DAP. The crop was destructively harvested at 60 DAP. After harvesting the crop, leaf samples were separated, cleaned, dried at $60^{O}C$ for 72 hours, weighed, ground and stored. Plant height, branches $plant^{-1}$, leaves $plant^{-1}$, leaf area $plant^{-1}$, fresh and dry leaf weight of stevia leaves were studied. N content was determined by micro Kjeldahl method (Page *et al*., 1982). Uptake was calculated from N content and leaf dry yield. The results obtained were subjected to statistical analysis using standard method of analysis (Steel *et al*., 1997). The differences among the treatment means were compared by using Duncan Multiple Range test (Gomez, 1984).

Results

Effects of foliar application of urea on the growth and leaf yield of stevia.

Seven doses of urea by foliar application were used to study the growth, yield components, leaf biomass yield, N content and uptake by stevia. The results are described under the following heads.

Plant height

The data on plant height as affected by different rates of foliar application of urea in acid and non-calcareous soil is given in Fig 1. Different urea rates had significant effect on plant height of stevia. The applications of urea influenced plant height variably from 15 to 60 DAP. There was a general trend of increase in plant height with increase in urea fertilizer at 15, 30, 45 and 60 DAP with the control treatment registering the least. In the first stage of growth, differences between urea levels were not significant. After this stage, increased plant height and difference between treatments could be observed. An increase in plant height was observed from planting stage to harvesting in both soils irrespective of treatments. Urea application at all levels increased plant height by 22 to 47cm in acid soil and 11 to 34cm in non-calcareous soil, respectively. It was observed that the pots subjected to $U_{1.0}$, $U_{1.5}$ and $U_{2.5}$ produced identical plant height but significantly different from those subjected to $U_{0.5}$ and $U_{3.0}$ including control at 60 DAP in acid soil. In case of non-calcareous soil, the plants fertilized with $U_{1.0}$ and $U_{1.5}$ produced identical plant height. Urea @ 2.0g produced the tallest plant (90.3cm) and the shortest plants formed in the control (without urea) treatment in both soils. Height increase was 107% higher in acid soil and 60% in non-calcareous soil over control.

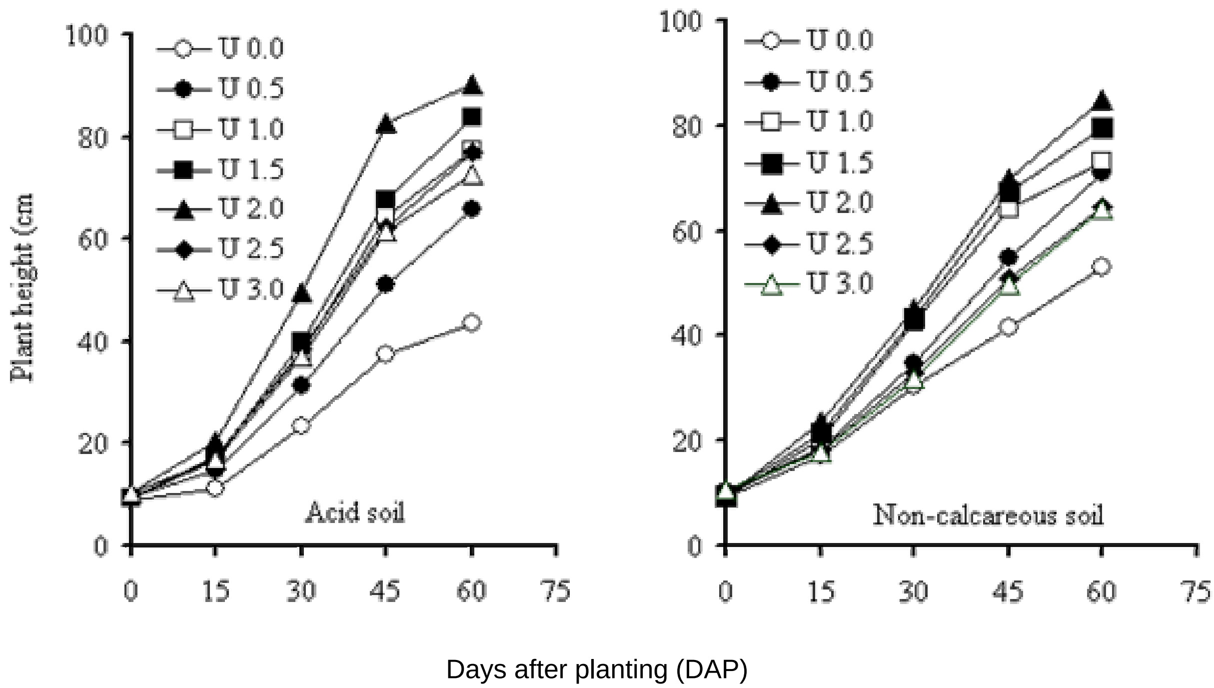
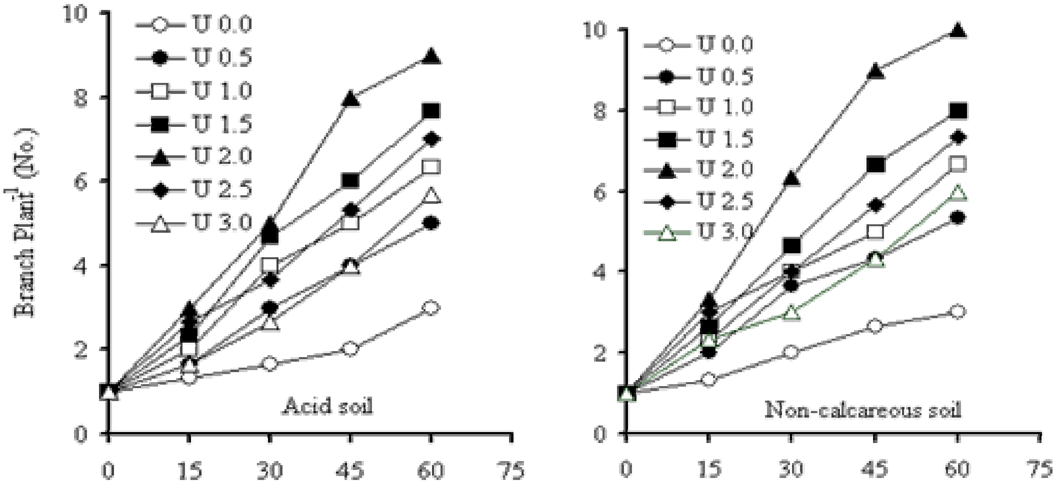


Fig. 1. Effects of different levels of foliar application of urea on the plant height of stevia at various DAP

Branch number

The data on branch number as influenced by different levels of urea are presented in Fig. 2. Branch number $plant^{-1}$ responded significantly due to the application of different levels of urea. The result revealed that branches $plant^{-1}$ progressively increased with increasing levels of urea application up to 2.0g in both soils and then declined with further addition. The application of urea influenced the number of branches $plant^{-1}$ variably from 15 to 60 DAP irrespective of soils and treatments. Rapid increase in branch number was observed between 15 and 45 DAP and then remained constant or very slowly increased in both soils. The highest number of branches $plant^{-1}$ (9.0 in acid soil and 10.0 in non-calcareous soil) at 60 DAP was counted from the plant receiving 2.00g urea which was identical with $U_{1.5}$ and $U_{2.5}$ but significantly different from other urea treatments including control. The lowest branch number was counted from the control treatment. Urea application at all levels increased branch number by 67-200% in acid soil and 77 to 233% in non-calcareous soil, respectively over control at 60 DAP.

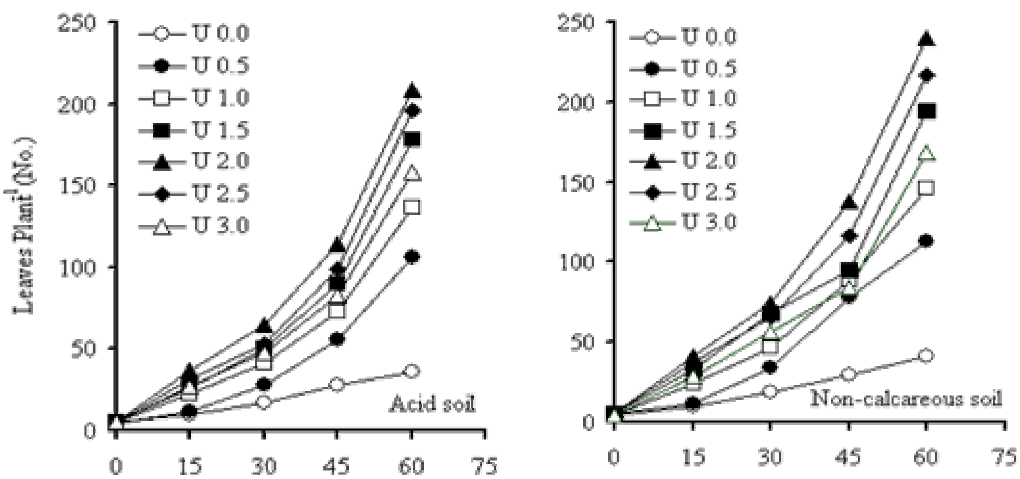


Days after planting (DAP)

Fig. 2. Effects of different levels of foliar application of urea on the branch number of stevia at various DAP

Leaf number

The data pertaining to the number of leaves plant^{-1} as influenced by different levels of urea in both acid and non-calcareous soils at various DAP have been presented in Fig. 3. Application of urea at different doses significantly influenced the number of leaves of stevia plants at all growth stages except 0 DAP irrespective of soils and treatments used. Leaf number was increased with the increased levels of urea up to 2.0g and then declined with further additions ($U_{2.5}$ and $U_{3.0}$). Leaf number increase was very slow at the early growth stages (0-30 DAP) while it was rapid between 30 and 60 DAP irrespective of urea levels except control. Urea application at all levels increased the number of leaves by 70 to 173 in acid soil and 72 to 199 in non-calcareous soil, respectively. Highest number of leaves was recorded when $U_{2.0}$ was applied which was identical with $U_{2.5}$ but significantly higher than all other levels of urea in both soils. Plants fertilized with $U_{2.5}$ and $U_{1.5}$ produced identical number of leaves in both soils. The lowest number of leaves plant^{-1} was harvested from the plants fertilized with no urea irrespective of soils and growth period.



Days after planting (DAP)

Fig. 3. Effects of different levels of foliar application of urea on the leaf number of stevia at various DAP

Leaf area

The data on total leaf area plant^{-1} at harvest as influenced by different levels of urea are presented in Table 2. Leaf area plant^{-1} responded significantly due to the application of different levels of urea. The result revealed that leaf area progressively increased with increasing levels of urea application up to 2.0g in both soils and then declined with further additions. The highest total leaf area plant^{-1} (1490cm^2 in acid soil and 1932cm^2 in non-calcareous soil) at 60 DAP was measured from the plant receiving 2.0g urea which was significantly higher than other levels of urea except $U_{1.5}$ and $U_{2.5}$. Second highest values of 1058cm^2 were obtained from the plant fertilized with $U_{2.5}$ in acid soil and 1266cm^2 from $U_{1.5}$ in non-calcareous soil. The lowest leaf area was found from the control treatment irrespective of soils used. Urea application at all levels increased leaf area by 236-798% in acid soil and 255 to 944% in non-calcareous soil, respectively over control at harvest.

Table 2. Effects of different levels of foliar application of urea on leaf area, dry weight and yield increase of stevia leaves over control at harvest

Urea level	Leaf area plant^{-1} (cm^2)		Leaf dry weight (g plant^{-1})		Increase over control (%)	
	Acid soil	Non-calcareous soil	Acid soil	Non-calcareous soil	Acid soil	Non-calcareous soil
$U_{0.0}$	166d	185c	1.08f	1.24f	-	-
$U_{0.5}$	558c	656bc	3.20e	3.41e	196	175
$U_{1.0}$	782bc	821bc	4.14d	4.41d	283	256
$U_{1.5}$	1007ab	1266ab	5.39bc	5.89bc	399	375
$U_{2.0}$	1490a	1932a	6.32a	7.26a	478	485
$U_{2.5}$	1058ab	1246ab	5.93ab	6.56ab	449	429
$U_{3.0}$	808bc	874bc	4.78cd	5.09cd	343	310
CV (%)	3	5	2.91	2.99	-	-
LSD	154	406	0.47	0.52	-	-
SE±	77	136	0.38	0.43	-	-

CV = Coefficient of variance, LSD = Least significant difference, SE± = Standard error of means

Fresh weight

The fresh weight of stevia leaves plant^{-1} at harvest varied significantly due the application of different levels of urea fertilizer (Fig. 4). Results revealed that fresh weight progressively increased with increasing levels of urea application up to 2.0g in both soils and then declined with further additions ($U_{2.5}$ and$U_{3.0}$). The highest fresh weight plant^{-1} (23.45g in acid soil and 26.93g in non-calcareous soil) at harvest was measured from the plant receiving $U_{2.0}$ which was identical with the fresh weights of the plants fertilized with $U_{2.5}$ but significantly higher than other levels of urea. Second highest values (22.00g in acid soil and 24.35g in non-calcareous soil) were obtained from $U_{2.5}$. The lowest values were obtained from the control treatment (4.00g in acid soil and 4.60g in non-calcareous soil) irrespective of soils used. Urea application at all levels increased fresh weight at harvest by 7.86 to 19.45g plant^{-1} in acid soil and 8.04 to 22.33g plant^{-1} in non-calcareous soil, respectively.

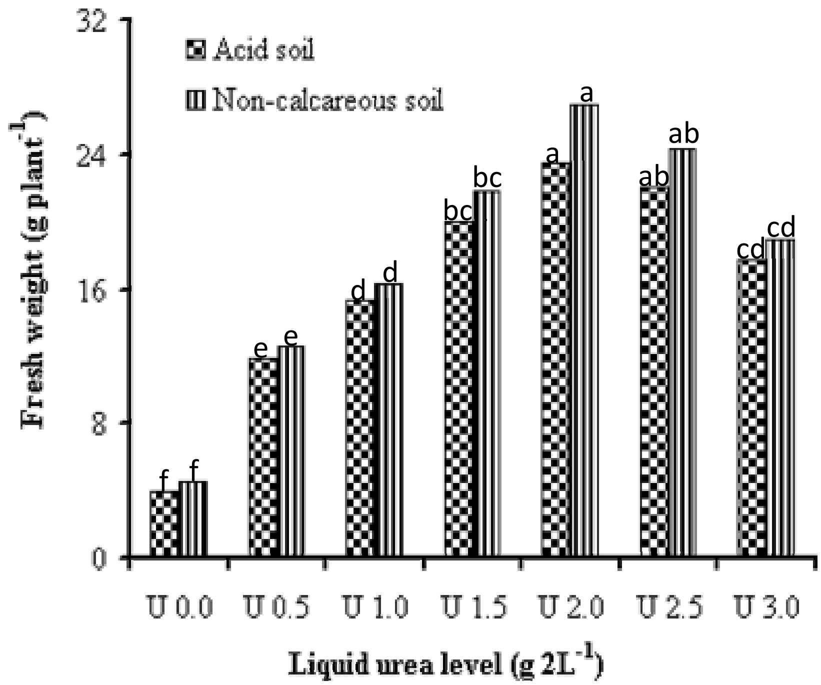


Fig. 4. Effects of different levels of foliar application of urea on the fresh weight of stevia leaves at harvest

Dry weight

The dry weight of stevia leaves plant^{-1} at harvest varied significantly due the application of different levels of urea fertilizer (Table 2). Results revealed that dry weight progressively increased with increasing levels of urea application up to 2.0g in both soils and then declined with further additions ($U_{2.5}$ and$U_{3.0}$). The highest dry weight plant^{-1} (6.32g in acid soil and 7.26g in non-calcareous soil) at harvest was measured from the plant receiving 2.0g urea which was identical with the dry weights of the plants treated with $U_{2.5}$ but significantly higher than other levels of urea. Second highest values (5.93g in acid soil and 6.56g in non-calcareous soil) were obtained from $U_{2.5}$. The lowest values were obtained from the control treatment (1.08g in acid soil and 1.24g in non-calcareous soil). Urea application at all levels increased leaf dry yield at harvest by 196 to 478% in acid soil and 175 to 485% in non-calcareous soil, respectively over control.

N content and uptake

Different levels of foliar application of urea significantly affected the N content and uptake by stevia leaf at harvest (Table 3). N content of the leaf was increased with the increased levels of urea irrespective of soils used. The highest N content (2.11% in acid soil and 1.99% in non-calcareous soil) was obtained when urea was applied @ 3g in both soils which was statistically identical with the N contents of the leaves of stevia plant fertilized with $U_{2.5}$ in non-calcareous soil but significantly different from other treatments. The lowest N content was obtained from the plants receiving distilled water only in both soils. The trend of N uptake did not follow the trend of N contents of stevia leaves. The N uptake varied from 12.64 to 104.91mg pot^{-1} in acid soil and 13.64 to 132.86mg pot^{-1} in non calcareous soil. N uptake as expected increased as foliar urea levels increased up to 2.0g and then decreased with further addition ($U_{2.5}$ and $U_{3.0}$). Like N content, the lowest uptake was observed in the control treatment of both soils.

Table 3. Effects of different levels of foliar application of urea on the N content and uptake by stevia leaf at harvest

N level	Nitrogen			
	Acid soil		Non-calcareous soil	
	Content (%)	Uptake (mg pot^{-1})	Content (%)	Uptake (mg pot^{-1})
$U_{0.0}$	1.17f	12.64d	1.10e	13.64e
$U_{0.5}$	1.19f	37.12c	1.37d	46.72d
$U_{1.0}$	1.33e	55.06c	1.55d	68.36c
$U_{1.5}$	1.48d	79.77b	1.71c	100.72b
$U_{2.0}$	1.66c	104.91a	1.83b	132.86a
$U_{2.5}$	1.81b	98.44a	1.92a	125.95ab
$U_{3.0}$	2.11a	100.86a	1.99a	101.29b
CV (%)	3.36	4.39	3.97	5.29
$LSD_{0.05}$	0.02	5.19	0.01	6.23
SE±	0.02	1.75	0.01	2.09

CV = Coefficient of variance, LSD = Least significant difference, SE± = Standard error of means

Discussion

Smaller quantities of the fertilizer material are required if is applied as foliar spray than that applied directly in the soil. The danger of fixation and/or leaching is also reduced when nutrients are applied to the foliage of the plant. Foliage generally absorbs nutrients more rapidly than when applied to the soil. The application of foliar fertilizer is the quickest way to deliver nutrients to the tissues and organs of the crops as well as the quickest means of replacing nutrient deficiencies. The results are discussed under the following heads.

Leaf yield and yield attributes

Foliar fertilization involves the application of soluble fertilizer to the foliage of crop plants, in the form of a diluted aqueous spray. From the applied solution, the plant takes up the nutrients in ionic form, through the leaves and other aerial organs. Supplying plants with adequate nutrition is an important aspect of maintaining their health and performance, and foliar sprays have been used for a long time as a source of the necessary nutrients. Foliar sprays can give the crops a nutritional boost that results in increased yields, higher quality, improved resistance to disease and insect attack, and enhanced drought tolerance. In this experiment, highest yield attributes viz. plant height, branch number, leaf area and leaf number, fresh and dry leaf yield of stevia were obtained when foliar urea was applied @ 2g and then remained constant or decreased. The lowest values of all the parameters were found in the control treatment. This result is in accordance with the findings of Khosha *et al*. (2011) who found highest plant height, branch number, leaf area and leaf number of gerbera applying liquid urea @ 2g L^{-1}. Yildrim *et al*. (2007) also reported highest values of all the studied parameters of broccoli from the foliar application of 1% urea solution. These results are in line with Khan *et al*. (2009) who reported that the foliar spray of 4% urea solution was most effective for enhancing the quantitative and qualitative traits when sprayed at tillering, stem elongation and booting stage. The grain yield was increased by 32% when 4% urea solution was applied as foliar spray. Further increase in the concentrations of urea spray was not useful and economical as it declined the grain yield by 25% or even more probably due to its toxicity.

N content and uptake

Different levels of foliar application of urea significantly affected the N content and uptake by stevia leaf at harvest. N content of the leaf was increased with the increased levels of urea irrespective of soils used. N uptake did not follow the trend of N content of stevia leaves. N uptake as expected increased with the increase in foliar application of urea up to 2.0g and then decreased with further addition ($U_{2.5}$ and $U_{3.0}$) irrespective of soils used. Both N content and uptake by stevia was higher in acid soil than non- calcareous soil.

Khan *et al*. (2009) reported that foliar application of urea significantly increased the N uptake by wheat. The foliar spray of 4% urea solution was found to be most effective dose for N uptake by wheat. The high efficiency of foliar urea application found in this study is in agreement with the findings of Yildrim *et al*. (2007) who found highest N uptake by broccoli leaf applying 1% urea solution. Zahran and Abdoh (1998) found better result for onion and Zeidan (2003) for faba bean. The later recommended that urea might be used as foliar N source to obtain better growth, yield, N content and uptake.

Conclusion

Foliar application of urea significantly increased yield attributes and leaf N content and uptake by stevia. Most of the parameters were increased with the advancement of growth period from 30 to 60 DAP. The foliar spray of 2.0g urea solution was found to be most effective for enhancing the growth, leaf yield and yield attributes of stevia. The yield increase was 478% in acid soil and 485% in non-calcareous soil over control. Further increase in the concentrations of urea spray (2.5 and 3.0g) was not found to be useful as it declined the leaf yield by 135% in acid and 175% in non-calcareous soil probably due to its toxicity. In regard to the N content, it can be inferred that foliar urea applications increased N content in stevia leaves irrespective of soils with the increased levels of urea. The highest values were obtained from 3.0g urea application for the plants grown in both soils. Conversely, the trend of N uptake did not follow the trend of N contents of stevia leaves. N uptake as expected increased as foliar application of urea increased up to 2.0g and then decreased with further addition.

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