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Strategy for crop regulation in guava (*Psidium guajava* L.) through foliar urea sprays and its effect on different N-forms in leaves

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Abstract

Different concentrations of fertilizer grade urea were applied foliarly on whole tree of guava cvs. Allahabad Safeda (0,10, 20, 25 and 30 %) and Sardar (0,20,25, and 30 %) at bloom stage (30^{th} April). Concentrations of 10 and 20 % were repeated after 10 days (10^{th} May) on the respective cvs. The effect of urea was apparent within two days by leaf scorching followed by abscission. Single application of 25 and 30 % urea virtually eliminated all the summer flower and flower buds within 12 days. This resulted in drastic reduction of rainy season fruit yield. Among the treatments, trees which received single treatment with 25 % urea produced higher yield (115.5 kg/tree) as compared to control (34.3 kg/tree) in cv. Sardar, while in cv. Allahabad Safeda, two applications of 10 % urea had the highest fruit yield (111.45 kg/tree) closely followed by single treatment with 20 percent urea (109.2 kg/tree). Urea – N concentrations in the leaves increased rapidly after foliar application. The maximum concentration was obtained at 4 days after application (except additional spraying of 10 and 20% urea) and after that concentration in the tissues declined to its original value within 32 days. An additional spraying with 10 and 20 percent (in cv. Allahabad Safeda and Sardar) showed highest increase in urea-N as compared to the value obtained in their corresponding single spray. Tissue ammonium concentrations also increased after foliar application of urea. NH_4^+- N reached a maximum by 4 days and showed decline there after. Similarly, NO_3^--N concentrations reached a maximum up to 12 days of application. After that, concentration declined within 32 days. Total N was higher in leaves than control during the investigation period. The amount of soluble N (NH_4^+-N and NO_3^--N) and urea-N was parallel to the increase in the concentration of urea-N. At fruit harvesting stage (mid - November), the level of urea-N, NH_4^+-N and total N in shoot and fruit approximately comes to its initial values which indicate that most of the urea-N and soluble N was utilized during leaf senescence, shoot initiation/ development, flower bud formation and fruit growth stage.

Key words: Guava, *Psidium guajava*, urea, crop regulation, yield, nitrogen fractions, N forms

Introduction

In India, there is an increasing demand from consumers and marketers for quality guava fruits. Fruits of the two most popular cultivars of guava grown in India, 'Allahabad Safeda' and 'Sardar' are intrinsically poor in quality during rainy season. On the contrary, winter season crop bears quality fruits which fetches high monetary returns (Singh *et al*., 2000). Obviously, regulation of crop will help to overcome such problems to a great extent by judicious flower thinning during summers.

Thinning manually (hand thinning) is invariably the best strategy as it enables accurate adjustments to be made of the crop load per tree and the spatial distribution of fruits within the tree especially for winter. Manual deblossoming (in summer) on a commercial scale is economically not viable. Many techniques have been used to induce new growth (on which flowers are born) by cultural manipulation and chemical thinner in guava (Shigeura *et al*., 1975; Singh *et al*., 1996; Singh *et al*., 1997) thereby controlling the time of flowering and subsequent fruit production during winter season.

In north Indian plains effective strategies are needed to make guava cultivation highly sustainable, profitable and export oriented. One possible strategy is to seek use of fertilizer grade urea as effective thinner, which could be more acceptable than other chemicals to guava growers. Few successful attempts have been made to regulate guava crop efficiently by foliar application of urea (Singh and Singh, 1994; Singh *et al*., 1995; Singh *et al*., 1996; Singh and Singh, 1997; Singh *et al*., 2000). In these studies, two foliar applications of urea were applied in April-May with concentrations ranging from 5 to 20 % to eliminate the rainy season crop. It was decided to test urea sprays, not only to avoid double application, but also to see if higher yield could be attained in different cultivars especially during winter season. It was felt that the information generated on the effect of single application of higher urea concentrations (25-30%) would be of practical utility for regulation of crop in guava. In Hawaii, Shigeura *et al*. (1975) and in Australia, Chapman *et al*. (1979) used a urea spray (25%) as a defoliant on guava to change the yield pattern from scattered bearing to a concentrated peak harvest during the desired period.

Oland (1963) has indicated the possible value of utilizing urea foliar sprays as a N source when applied shortly before leaf fall. The advantages of applying urea in the leaf fall, compared with early in the growing season is that much more leaf surface is present and the N is not diverted into unnecessary vegetative growth. It was also demonstrated by Kato (1986) and Mooney and Richardson (1992) that as much as 80% of the N utilized during the spring and fruit set period is derived from storage (reserve), N. In present investigation, the timing of foliar application of urea is spring which probably contributes significantly towards absorption of urea by leaves and also utilization for the emergence of new shoots on which flower buds are formed for the following winter.

During the autumn, leaves before abscission export part of their nitrogen through the phloem to the trunk and root system (Shim *et al*., 1972). Foliar urea applications to fruit trees at this time have not only increased N storage and stimulated shoot growth during the following season (Hen *et al*., 1989; Shim *et al*., 1972), but also have accelerated leaf abscission particularly when high rates were used (Terblanche *et al*., 1970). The main objective of the following experiment was to ascertain that foliar urea applied as the sole N source can promote the shoot growth of guava and to determine the fate of this foliarly applied urea.

Materials and methods

Twenty year old trees of guava cvs. Allahabad Safeda and Sardar spaced at 5 x 5m (400 trees ha^{-1}) were used to evaluate different concentrations of fertilizer grade urea as potential leaf, flower and flower bud thinner. Whole trees of Sardar and Allahabad Safeda were sprayed at bloom stage with 20, 25 and 30 % of urea (46% N) for Sardar and 10, 20, 25 and 30 % for Allahabad Safeda on 30^{th} April. Concentrations of 10 and 20 % were repeated after 10 days on Allahabad Safeda and Sardar, respectively. The surfactant, Tween 20 (Polyoxyethylene sorbitan monolaureate) was included with all sprays. Each tree was sprayed with 8 litres of solution, using a Maruti foot operated sprayer (450 m1/min^{-1}) equipped with a Duromist spray nozzle. All treatments (4 in Sardar and 5 in Allahabad Safeda) were replicated 5 times within randomised blocks. In order to assess the various concentrations, all trees received similar treatment with respect of fertilization, irrigation and plant protection measures. Four uniform size branches, spread in all directions, were randomly selected and kept under constant observation for abscission of leaf and flowers. For determination of urea-N, NH_4^+-N and NO_3^--N, guava leaf samples were collected up to a period of 32 days (from the date of spraying) at 4 days intervals. The leaf samples were analysed for urea-N (Douglas & Bremner, 1970), NH_4^+-N and NO_3^- -N (Chapman and Pratt, 1966) and total N was analysed by standard AOAC procedure (1984).

Results and discussion

Pattern of abscission: The pattern of abscission varied considerably with different concentrations (Table 1 and 2). Leaf and flower abscission occurred after 2 days of urea spray in both the cultivars. The effect was apparent after 4 days of spray where most of the foliage showed marginal burn and the flowers either dropped or dried. Leaf damage is the main factor that limits the total amount of N that can be supplied through foliar application of urea. Understanding the cause of urea phytotoxicity is critical for improving the efficiency for this method of N supply. Hinswark *et al*. (1963) observed that ammonium accumulation may cause leaf injury when excessive urea is used. Toxicity related to foliar application of urea has been reported for several species (Barel and Black, 1979) and may be caused by the direct effects of urea or by NH_4^+ released by urease. Krogmeir *et al.* (1989) demonstrated that phytotoxicity was the direct effect of urea, rather than of NH_4^+. In our study, maximum abscission occurred within 4 to 8 days when the concentrations of urea – N

Table 1. Abscission pattern (leaves and flowers) for Sardar guava trees in response to fertilizer grade urea

Urea conc. (%)	Plant part	Abscission (%) at different days after urea spray 4	8	12	16	20	24	28	32
Control	L	0.64	0.64	3.63	7.02	7.02	7.02	7.02	7.02
	F	32.90	35.46	45.36	55.62	55.62	55.62	55.62	55.62
20 (X)	L	20.52	53.03	92.94	99.25	0.00	0.00	0.00	0.00
	F	29.90	51.32	97.93	0.00	0.00	0.00	0.00	0.00
25 (Y)	L	23.52	80.01	92.00	94.00	95.86	97.21	98.28	98.28
	F	39.66	61.53	97.22	97.22	0.00	0.00	0.00	0.00
30 (Y)	L	18.97	84.32	95.10	97.19	98.19	98.79	0.00	0.00
	F	32.90	97.22	0.00	0.00	0.00	0.00	0.00	0.00
CD	L	3.90	12.30	2.09	NS	NS	NS	NS	NS
(p=0.05)	F	2.60	9.20	1.90	NS	NS	NS	NS	NS

Table 2. Abscission pattern (leaf and flowers) for Allahabad Safeda guava trees in response to fertilizer grade urea

Urea conc. (%)	Plant part	Abscission (%) at different days after urea spraying 4	8	12	16	20	24	28	32
Control	L	2.58	2.58	5.63	6.00	6.00	6.00	6.00	6.00
	F	19.23	19.23	39.25	54.93	54.93	54.93	54.93	54.93
10 (X)	L	16.03	33.67	67.66	78.55	83.00	87.00	89.00	89.00
	F	25.65	48.81	77.07	92.63	0.00	0.00	0.00	0.00
20 (Y)	L	24.68	63.93	81.33	83.10	88.00	94.00	95.00	95.00
	F	54.93	94.15	98.33	99.37	0.00	0.00	0.00	0.00
25 (Y)	L	25.72	72.75	87.96	93.01	94.00	94.00	95.97	95.97
	F	48.58	75.08	97.22	98.89	0.00	0.00	0.00	0.00
30 (Y)	L	36.64	74.33	89.37	93.30	95.00	95.00	0.00	0.00
	F	49.90	91.69	0.00	0.00	0.00	0.00	0.00	0.00
CD	L	4.50	1.02	2.00	0.02	NS	NS	NS	NS
(*p*=0.05)	F	5.90	1.08	1.60	0.03	NS	NS	NS	NS

X=Double spray (30^{th} April and 10^{th} May), Y =Single spray (30^{th} April) and NH_4^+ -N reached from 45.45 to 7500 ppm and 28 to 1888.88 ppm in Sardar (Fig. 1) and 35.45 to 5500 ppm and 25.9 to 2717.39 ppm in Allahabad Safeda (Fig. 2), respectively. Single application of urea (25 and 30%) virtually eliminated all the summer flowers within 12 days of urea application. More than 70% flower dropped within 8 days of urea application in both the cultivars. The treatment of fertilizer grade urea (30%) produced severe foliage burn in both the cultivars, which might be phytotoxic at sufficiently high concentration (Klien and Zilkah, 1986) and defoliation (Zilkah *et al.*, 1987). Shigeura *et al.* (1975) and Chapman *et al.* (1979) reported that urea (25%) was an optimum concentration for defoliation and subsequent fruit set resulting early cropping in guava. Addicott (1964) indicated that most defoliants have no direct effect on the abscission zone, but induces abscission by way of leaf injury which sets in motion the chain of events leading to leaf fall. This abscission may be caused by the direct effects of urea or by NH_4^+ released by urease. Moreover, the presence of high levels of NH_4^+-N after urea application to guava leaves can also, at least partially, be responsible for inhibiting growth through feed back inhibition of urease activity. Puritch and Barker (1967) noticed that the structure of chloroplast is affected under conditions of ammonium toxicity, which might be a probable cause of phytotoxicity.

Urea utilization: Fig. 1 and 2 indicate that all the concentrations of urea applied (twice or single) increased urea-N markedly in the leaves of both the cultivars. It was observed that the spraying of urea concentration at 10, 20, 25 and 30% to guava leaves caused a transient increase in the leaf tissue urea. This transient increase was probably caused by rapid urea uptake, which increased the urea concentration, followed by rapid hydrolysis, which decreased it. The urea - N content in senescing leaves increased up to 4 days after trees had foliar urea application. After that the concentration of urea-N declined rapidly in both the cultivars. A small amount of urea- N remained in the leaf tissue by 32 days. An additional spraying with 10 % urea solution in Allahabad Safeda and 20 % in Sardar had shown highest increase in urea N up to 12 days after spraying as compared to the values obtained in their corresponding single spray. Other workers have also observed the absorption of urea - N parallel to the amount of urea applied in other crops like apple (Shim *et al.,* 1972).

The bulk of the soluble N fraction was urea-N and the changes in soluble N paralleled the changes in urea-N. A perceptible increase in NH_4^+ - N in the guava leaves was obtained at all the concentrations of urea either with single or double spray in both the cultivars (Fig. 1 & 2). In contrast with urea -N concentration, the NH_4^+-N remained high after their initial increase by 12 days of application. Whether these stable NH_4^+- N concentrations are caused by the continuous generation of NH_4^+ from urea hydrolysis or by an inhibition of NH_4^+ assimilation is unknown. After 20 days, a steady decline in NH_4^+- N with time was observed which might be due to its conversion into NO^-_3-N.

The changes in the content of urea -N and soluble N (NH_4^+-N and NO_3^--N) indicated that the hydrolysis of urea was not completed even up to 24 days in the guava leaves. Overall, there is sharp increase in leaves of urea-N and NH_4^+-N in leaves temporarily after foliage sprays of urea. The level rises and attains the peak value up to 4 days and afterwords showed declining trend. By the end of 32 days sampling period, the soluble N (NH_4^+-N and NO_3^-) had doubled in amount as compared to initial value (0 days). Foliar urea treatments resulted significantly higher leaf N than nontreated trees. During 8 to 20 days after urea application, leaf N was higher when trees received higher concentration of urea (>20%). It is interesting to note that at fruit harvest stage, urea – N, NH_4^+-N and NO_3^--N declined drastically and the values obtained for urea-N, NH_4^+-N and NO_3^--N were 77.0, 498.78 and 326.58 ppm in Allahabad Safeda and 61.59, 548.54 and 357.40 ppm in Sardar as compared to 69.74, 439.30 and 267.60 and 55.25, 466.00 and 316.90 ppm under control trees of Allahabad Safeda and Sardar, respectively (Table 3).

Concentrations of 10 to 30 % of the applied to the guava tree canopies was utilized by either in abscissied leaves or in perennial tree parts. The present results indicate that most of the concentration of urea – N was utilized during abscission, shoot development, flower bud formation and fruit growth. Similarly, in nectarine and peach leaves rapid absorption of foliar-applied urea, irrespective of application date has been reported for many other fruit trees (Swietlik and Faust, 1984).

Yield and fruit quality: Considering rainy season fruit yield per tree, all the tested treatments either applied as single or double spray effectively eliminated the rainy season crop in comparison to control (Table 4). The fruit yield during rainy season was maximum on the unsprayed controls, which yielded an average of 92.41 and 39.95 kg per tree as compared to 16.85 to 32.53 and 1.26 to 5.39 kg per tree under urea treated trees of Sardar and Allahabad Safeda, respectively. Of the different treatments, trees which received single treatment with 25 % urea produced significantly higher yield (115.5 kg/tree) during winter in Sardar. It has been observed that single sprayed trees with 25% urea and double application of 10 % urea in Allahabad Safeda gave 3 times more yield over the control. In trees, where maximum number of flowers and flower buds developed, the yield did not follow the same pattern during the winter season. It was further observed that there was no direct association between the percentage of flower abscission and yield during winter. Defoliation with 25% urea sprays (Shigeura *et al.*, 1975; Chapman *et al.*, 1979; Shigeura and Bullock, 1976) has been achieved to change the yield pattern from scattered bearing to a commercial peak harvest during desired period. Significant differences were observed in qualitative characters (Table 3) with different concentrations of urea. Fruit weight was highest with 25 and 10 % urea in Sardar and Allahabad Safeda. Fruit harvested from double sprayed trees of 10 percent and single application with 25 % urea had highest TSS (11.0-11.20^{0}B), ascorbic acid (206.4 – 276.31 mg/100g) and reducing sugar (4.40 – 4.0%).

In conclusion, crop regulation in guava with the help of single spray of 25% and double sprays of 10% in Sardar and Allahabad Safeda, respectively at bloom stage (April-May) has been found economically efficient for quality production. These treatments did not affect the tree adversely, the fruit quality was better as the fruiting was mainly concentrated in winter. It has also been observed that urea spray suppressed shoot growth, producing severe leaf fall followed by initiation of new shoot on which flower buds are formed for following winter season. The concentration of urea-N and soluble N (NH^+_4-N and NO^-_3-N) in the plant tissue increased rapidly upto 4 days. After that concentration in the tissue declined to its original value within 32

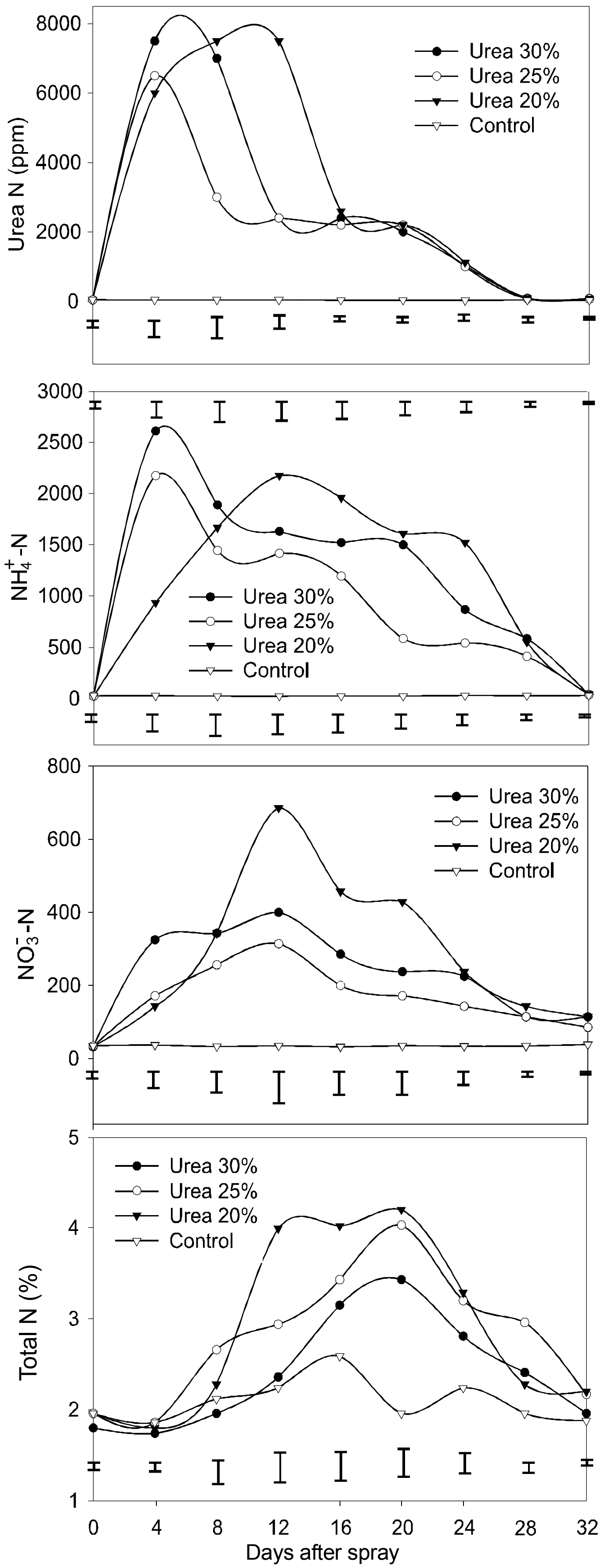

Fig. 1. Changes in different N fractions in leaves of cv. sardar at different inteval. Vertical bars are LSD values (*p*=0.05) on respective sampling date

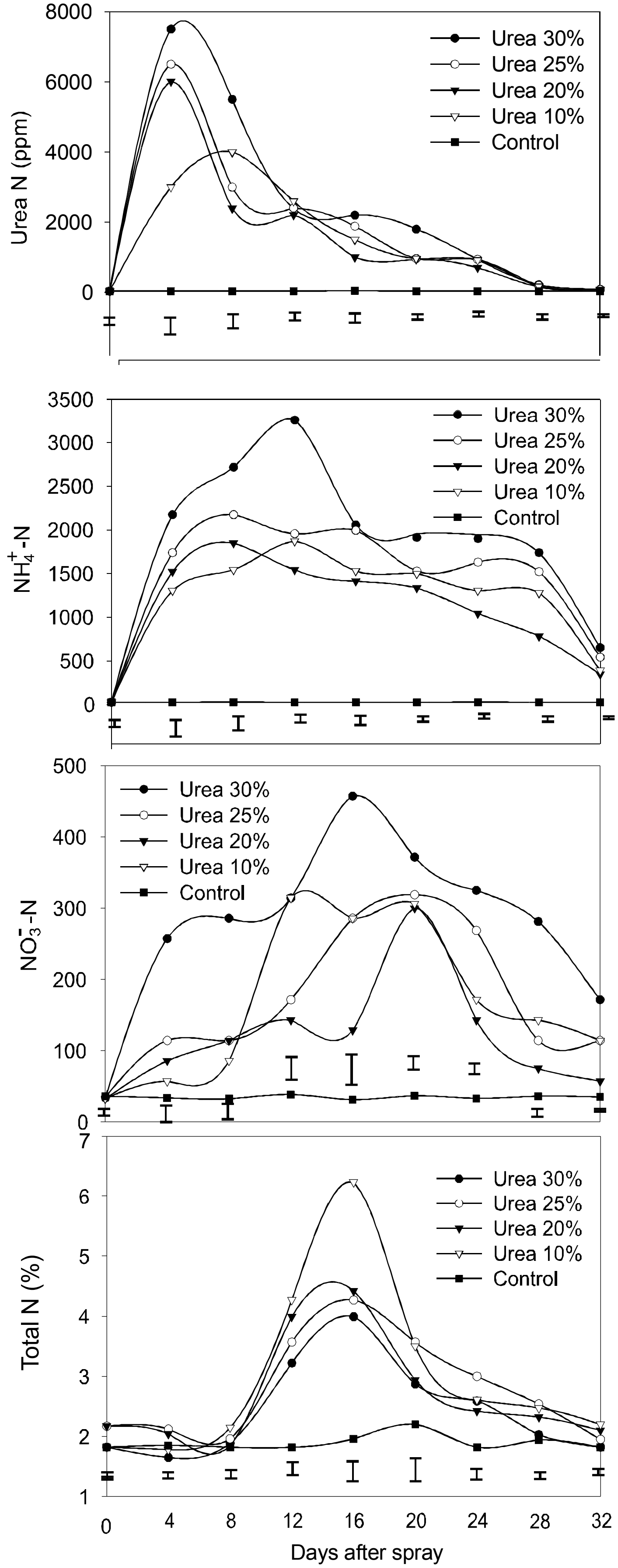

Fig. 2. Changes in different N fractions in leaves of cv. Allahabad Safeda at different inteval. Vertical bars are LSD values (*p*=0.05) on respective sampling date

Table 3. Urea – N, NH_4^+ - N and NO_3^-- N in the shoot and fruits of guava at harvest stage

Treatments	Urea-N (ppm)		NH_4^+-N (ppm)		NO_3^- - N (ppm)	
	Shoot	Fruit	Shoot	Fruit	Shoot	Fruit
Allahabad Safeda						
Control	135.05	69.74	616.90	439.30	590.30	267.60
Urea 10%(Double)	182.16	77.00	856.47	498.78	761.28	326.58
Urea 20%(Single)	175.25	105.97	778.60	470.86	725.80	289.60
Urea 25%(Single)	223.61	146.25	890.54	601.94	785.48	332.70
Urea 30% (Single)	229.40	190.22	1207.71	654.12	858.06	355.60
CD (p=0.05)	14.03	4.50	21.50	9.60	16.20	12.20
Sardar						
Control	135.05	55.25	663.70	466.00	658.10	316.90
Urea 20%(Double)	232.41	103.26	1305.96	595.87	851.66	429.60
Urea 25% (Single)	163.94	61.59	837.06	548.54	762.90	357.40
Urea 30% (Single)	195.98	64.30	1011.19	360.90	567.96	848.50
CD (p=0.05)	15.61	3.90	26.19	7.90	11.20	6.90

Table 4. Fruit yield, fruit weight, TSS, ascorbic acid and reducing sugar for Sardar and Allahabad Safeda guava fruits in response to fertilizer grade urea

Urea concentration (%)	Cultivar	Yield (kg/plant)		Fruit wt. (g)	TSS Brix	Ascorbic acid mg/100g	Reducing Sugar (%)
		Rainy season	Winter season				
0	A	92.41	32.15	175.35	10.60	199.20	3.65
	S	39.95	37.10	150.00	10.00	19813.	4.07
10	A	5.39	111.45	157.14	11.00	206.40	4.40
	S						
20	A	32.53	97.50	186.50	11.00	256.00	4.05
	S	4.16	109.20	147.50	10.00	187.20	4.30
25	A	22.88	115.50	191.50	11.20	276.31	4.00
	S	1.65	86.75	126.00	9.00	184.00	4.25
30	A	16.85	92.85	166.50	10.00	184.80	3.72
	S	1.26	79.13	118.00	7.00	180.00	4.27
CD (*p*=0.05)	A	7.00	13.00	15.00	0.02	8.00	0.05
	S	0.90	8.00	21.00	0.03	7.00	0.02

A= Allahabad Safeda and S=Sardar

days. At fruit harvesting stage, the concentration urea-N and soluble N in fruits was found to be similar with untreated control fruits.

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