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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(7): 464-468

www.thepharmajournal.com
Received: 05-04-2023
Accepted: 15-05-2023

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Effect of different doses of urea and nano-urea on growth and yield of guava (*Psidium guajava* L.) Cv. Lucknow-49

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Abstract
The current investigation was undertaken at Fruit Research Station, Sakkarbaug Farm, Junagadh Agricultural University, Junagadh during the year 2022. The study unveiled that highest incremental plant spread (E-W) (0.72 m), number of fruits per plant (93.93), fruit yield per plant (16.22 kg) and yield per hectare (12.01 tonnes) were noted in 100% RDN (U_1). Regarding nano-urea, maximum fruit set (75.33%), number of fruits per plant (102.58), fruit yield per plant (18.64 kg) and fruit yield per hectare (13.81 tonnes) were registered in 0.1% nano-urea (N_1). For interaction effect, maximum number of fruits per plant (112.00), fruit yield per plant (18.66 kg) and yield per hectare (13.82 tonnes) were reported in 100% RDN + 0.1% nano-urea (U_1N_1). While, maximum incremental plant height (0.83 m) and plant spread (E-W) (0.91 m) were found in 100% RDN + 0.6% nano-urea (U_1N_5) and maximum incremental plant spread (N-S) (1.43 m) was noted in 80% RDN + 0.6% nano-urea (U_2N_5). From present study, it can be inferred that an application of 100% RDN with 0.1% nano-urea increased fruit yield per plant and per hectare in guava.

Keywords: Guava, urea, nano-urea, growth, yield

Introduction
Guava (*Psidium guajava* L.) belongs to the family of 'Myrtaceae' having chromosome no. 2n=22. It is also identified by the name "Apple of tropics" is one of the most common fruits in India. Guava is a native of Tropical America (Mexico) and is commercially grown now in India, U.S.A., South America, Egypt, South Africa and Thailand. The total area under cultivation of guava in India is around 2.87 lakh hectare with an annual production of 30.40 lakh MT (Anon., 2020) [3]. In Gujarat, it is cultivated on large scale, ranked second after citrus and occupies an area 14,326 ha with an annual production of 1.75 lakh MT (Anon., 2021) [4]. Many varieties are under commercial cultivation in the country as well as in the Gujarat (Varu *et al.* 2020b) [31]. The area under commercial cultivation of guava is increasing day by day which requires the quality planting materials. It is only possible through multiplication of plants by different propagation methods. Among them, soft wood grafting is the good and fast method for the multiplication of healthy planting materials (Vasava, *et al.* 2023 and Anwarulhaq *et al.* 2021a) [33, 5].

Guava jelly is well known to all and it can be canned in sugar syrup of made into fruit butter. Its juice is used for the preparation of sherbets and ice cream. The roots, bark, leaves and immature fruits, because of their astringency are commonly employed to halt gastroenteritis, diarrhea and dysentery.

Nano materials are defined as materials with a single unit between 1 and 100 nm in size in at least one dimension (Liu and Lal, 2015) [16]. Hence, nano-fertilizers are either NMs which can supply one or more nutrients to the plants resulting in enhanced growth and yield or those which facilitate for better performance of conventional fertilizers, without directly providing crops with nutrients (Liu and Lal, 2015) [16]. Nano-fertilizers can possibly enter the plant cells directly through the sieve-like cell wall structures if the particle sizes are smaller than the sizes of cell wall pores (5-20 nm). The use of nano-fertilizers causes an increase in their efficiency, reduces soil toxicity, minimizes the potential negative effects associated with over dosage and reduces the frequency of the application.

Nitrogen plays important roles in plant growth and development as well as in fruit yield and quality, being required for chlorophyll and enzyme synthesis and constituting a component of proteins, metabolites and nucleic acids (Barker and Pilbeam, 2007; Titus and Kang, 1982) [9, 28].

Regarding nitrogen fertilizers, the application of nanotechnology can provide fertilizers that release nitrogen when crops need it. Hence, nano-technology has a high potential for achieving sustainable agriculture especially in developing countries.

Materials and Methods

The present investigation was carried out at Fruit Research Station, Sakkarbaug Farm, Junagadh Agricultural University, Junagadh during the year 2022. The trail was set up in a Factorial Randomized Block Design with control vs rest concept. Factor A consist with two nitrogen fertilizer doses: U_1-100% RDN and U_2-80% RDN. Whereas, factor B consist with different nano-urea concentrations: N_1-0.1% Nano-urea, N_2-0.2% Nano-urea, N_3-0.4% Nano-urea, N_4-0.5% Nano-urea and N_5-0.6% Nano-urea and control (RDF). The trial was replicated three times. The present study used 3 years old guava trees of the variety Lucknow-49. The treatments were applied with foliar spray of nano-urea at before flowering, at full bloom and two weeks after second spray and necessary observations were recorded. The recommended dose of fertilizers and other package of practices for guava were imposed uniformly for all the treatments including control.

Result and Discussion

Effect of different levels of urea and nano urea with their interaction effect and also control vs rest on growth and yield and yield attributing parameters are depicted in Table 1 and 2.

Growth parameters

Effect of urea

Effect of urea significantly improved in the growth parameters such as incremental plant height and incremental plant spread (N-S and E-W) but non-significant for leaf area and chlorophyll content.

The maximum incremental plant height (0.72 m) was observed in 80% RDN (U_2) which was at par with 100% RDN (U_1). Similarly, maximum incremental plant spread (N-S) (0.93 m) was also noted in 80% RDN (U_2) followed by 100% RDN (U_1). In addition, highest incremental plant spread (E-W) (0.72 m) was noted in 100% RDN (U_1) but it was at par with 80% RDN (U_2). The variation in different treatments might be due to nitrogen has a positive role in increasing the activity of meristematic tissues, cell division and its importance in building amino acids such as tryptophan, which is the basis for building auxins that contribute to cell division and expansion. The results are in accordance with the finding of Rana and Chandel (2003) [23] in strawberry and Alqader *et al.* (2020) [2] in broad bean, Mishra and Varu (2022) in pomegranate and Varu and Chovatia (2017) [29] in guava.

Effect of nano-urea

Effect of nano-urea significantly improved in incremental plant height and incremental plant spread (N-S and E-W). Whereas, leaf area and chlorophyll content were recorded non-significant.

Significantly highest incremental plant height (0.82 m) and incremental plant spread (N-S) (1.03 m) were observed in 0.5% nano-urea (N_4), but which was at par with 0.6% nano-urea (N_5). In case of incremental plant spread (E-W) (0.89 m), the result was found maximum in 0.6% nano-urea (N_5) followed by 0.4% nano-urea (N_3). The variation may be because of large dose of nano-nitrogen fertilizer boosts the synthesis of auxins, which promotes cell division and elongation across the entire vegetative plant. This directly affects the plant's height and other growth attributing traits. Such type of variability was recorded by Singh and Kumar (2017) [25] in sunflower and Al-Gym and Al-Asady (2020) [1] in yellow corn.

Interaction effect of urea and nano-urea

Result revealed that the interaction effect of urea and nano-urea was reported significant in incremental plant height and incremental plant spread (N-S and E-W) and it was noted non-significant for leaf area and chlorophyll content.

Significantly maximum incremental plant height (0.83 m) was noted in treatment combination of 100% RDN + 0.6% nano-urea (U_1N_5) and 80% RDN + 0.5% nano-urea (U_2N_4), which was at par with treatment combination U_1N_4 and U_2N_5. The maximum incremental plant spread (N-S) (1.43 m) was noted in treatment combination of 80% RDN + 0.6% nano-urea (U_2N_5) followed by 80% RDN + 0.5% nano-urea (U_2N_4). Highest incremental plant spread (E-W) (0.91 m) was noted in treatment combination of 100% RDN + 0.6% nano-urea (U_1N_5) followed by 80% RDN + 0.6% nano-urea (U_2N_5). This increase in growth parameters might be due to both soil and foliar application which leads to vigorous growth. Increased growth of tree with nitrogen application may be attributed to increased formation and accumulation of proteins in the plants. These findings are in agreement with those of Chadha (1969) [11] in guava, Rawat (1974) [24] and Badyal (1980) [8] in plum.

Control v/s Rest

Control vs rest was also found significant in incremental plant height, leaf area and chlorophyll content. While, incremental plant spread (N-S and E-W) was observed non-significant.

Highest incremental plant height (0.71 m) was reported in rest of treatment as compared to control (0.49 m). This might be due to increasing level of fertilizer and nano-fertilizer application was observed to increase growth of plants. In conformity with the similar variations observed by Bhari *et al.* (2000) [10] in mustard and Babatola *et al.* (2002) in okra.

Leaf area was reported highest (89.65 cm^2) in rest of treatment as compared to control (62.73 cm^2). The reason behind that is nano urea easily enters through stomata when sprayed on leaves and other openings and is assimilated by the plant cells. It is easily distributed through the phloem from source to sink inside the plant as per its need. Unutilized nitrogen is stored in the plant vacuole and is slowly released for proper growth and development of the plant. The result was supported by Rawat (1974) [24] and Joon (1989) [15] in plum and Eleiwa *et al.* (2012) [12] in potato.

Highest chlorophyll content (48.45 SPAD) was noted in rest of treatment as compared to control (46.12 SPAD). This might be due to the presence of nitrogen as a basic component may lead to the production of a nitrogen-rich material. Furthermore, utilizing nano-urea may enhance chlorophyll content in plant cells via reinforcing tetra pyrrole ring biosynthesis, which plays a pivotal biochemical role in chlorophyll synthesis. The results are in consonance with Eleiwa *et al.* (2012) [12] in potato and Aziz *et al.* (2016) [6] in wheat.

Table 1: Effect of different doses of urea and nano urea on growth parameters of guava

Sr. No.	Treatments	Incremental plant height (m)	Incremental plant spread (m)		Leaf area (cm^2)	Chlorophyll content (SPAD)
			N-S	E-W		
Factor A-N Fertilizer doses						
U_1	100% RDN	0.69	0.71	0.72	89.98	48.48
U_2	80% RDN	0.72	0.93	0.71	89.33	48.43
S.Em.±		0.008	0.016	0.005	1.609	0.470
C.D. at 5%		0.03	0.05	0.014	NS	NS
Factor B-Different nano-urea concentrations						
N_1	0.1% Nano-urea	0.74	0.74	0.61	82.33	49.56
N_2	0.2% Nano-urea	0.67	0.68	0.59	92.01	48.89
N_3	0.4% Nano-urea	0.50	0.64	0.77	92.90	47.56
N_4	0.5% Nano-urea	0.82	1.03	0.70	88.98	47.94
N_5	0.6% Nano-urea	0.81	1.02	0.89	92.05	48.32
S.Em.±		0.013	0.025	0.007	2.544	0.744
C.D. at 5%		0.04	0.07	0.02	NS	NS
Interaction: U × N						
S.Em.±		0.019	0.035	0.010	3.598	1.052
C.D. at 5%		0.06	0.10	0.030	NS	NS
Control v/s Rest						
Treatment mean		0.71	0.82	0.71	89.65	48.45
Control mean		0.49	0.86	0.65	62.73	46.12
S.Em.±		0.029	0.027	0.026	0.315	0.116
C.D. at 5%		0.08	NS	NS	0.93	0.34
C.V. %		6.26	7.01	7.02	6.78	3.83

Yield and yield attributing parameters

Effect of urea: The data from investigation revealed that application of urea exerted to be influence on yield and yield attributing parameters *viz*., number of fruits per plant, yield per plant and yield per hectare, while fruit set and fruit drop per cent were found non-significant.

Significantly maximum number of fruits per plant (93.93), fruit yield per plant (16.22 kg) and yield per hectare (12.01 tonnes) was noted in 100% RDN (U_1) followed by 80% RDN (U_2). The response to nitrogen fertilizer application might be due to the fact that nitrogen is needed in photosynthesis and in the formation of carbohydrates. It is supported by the results of Py and Teisson (1987) [20] in pineapple and Ramniwas *et al.* (2012) [22] in guava, Varu (2020) [32] and Varu *et al.* (2020) [32] in papaya and Suraj Kumar *et al.* (2022) Parsana *et al.* (2023) [19] in guava.

Effect of nano-urea

The variation due to different treatments of nano-urea was found significant in yield and yield attributing parameters such as fruit set, fruit drop, number of fruits per plant, yield per plant and yield per hectare.

Significantly maximum fruit set (75.33%) and minimum fruit drop (24.67%) were observed in 0.1% nano-urea (N_1), which was at par with 0.2% nano-urea (N_2). Similarly, maximum number of fruits per plant (102.58), fruit yield per plant (18.64 kg) and fruit yield per hectare (13.81 tonnes) was obtained in 0.1% nano-urea (N_1) followed by 0.2% nano-urea (N_2). This might be due the fact that nano fertilizers is quick absorbed by the plant and translocated at a faster rate which resulted in higher rate of photosynthesis and more dry matter accumulation. These findings agreed with reports of Tarafdar *et al*. (2014) [27] in pearl millet and Hafeez *et al.* (2015) [14] in wheat.

Interaction effect of urea and nano-urea: Similar trend of urea was also noted in interaction effect and variation due to different treatments was found significant in parameters like number of fruits per plant, yield per plant and yield per hectare. Meanwhile, fruit set and fruit drop per cent were found non-significant.

Maximum number of fruits per plant (112.00) was noted in treatment combination of 100% RDN + 0.1% nano-urea (U_1N_1) followed by 100% RDN + 0.2% nano-urea (U_1N_2). Likewise, maximum fruit yield per plant (18.66 kg) and yield per hectare (13.82 tonnes) were also obtained in treatment combination of 100% RDN + 0.1% nano-urea (U_1N_1) which was at par with U_2N_1 and U_2N_2. The increases found in fruit set, number of fruits per tree and crop yield with foliar nitrogen fertilization can be attributed to the physiological and metabolic roles of nitrogen in flowering and fruit set, including supplying carbohydrates, which are necessary for flower bud growth, flower initiation and development, ovule lifespan, effective pollination and fertility. The results are in accordance with the finding of Lovatt (1994) [17] in avocado, Stiles (1999) [26] and Etehadnejad and Aboutalebi (2014) [13] in apple.

Control v/s Rest

The result of control vs rest was found significant in yield and yield attributing parameters such as fruit set, fruit drop, yield per plant and yield per hectare. However, number of fruits per plant was observed non-significant.

Maximum fruit set (72.82%), fruit yield per plant (15.80 kg) and fruit yield per hectare (11.70 tonnes) and lower fruit drop (27.18%) were found in rest of treatment as compared to control.

The positive influence of increased nitrogen utilization on yield attributing character is most likely the reason for the increase in yield. These results are in conformity with Rajesh *et al.* (2021) [21] in fodder oats and Velmurugan *et al.* (2021) [34] in rice.

Table 2: Effect of different doses of urea and nano urea on yield and yield attributing parameters of guava

Sr. No.	Treatments	Fruit set (%)	Fruit drop (%)	Number of fruits/plant	Yield (kg/plant)	Yield (t/ha)
Factor A-N Fertilizer doses						
U_1	100% RDN	73.41	26.59	93.93	16.22	12.01
U_2	80% RDN	72.24	27.76	79.30	15.37	11.39
S.Em.±		0.483	0.397	0.944	0.248	0.184
C.D. at 5%		NS	NS	2.80	0.73	0.54
Factor B-Different nano-urea concentrations						
N_1	0.1% Nano-urea	75.33	24.67	102.58	18.64	13.81
N_2	0.2% Nano-urea	73.54	26.46	90.50	16.35	12.11
N_3	0.4% Nano-urea	72.76	27.24	89.50	16.14	11.96
N_4	0.5% Nano-urea	71.31	28.69	78.42	14.37	10.64
N_5	0.6% Nano-urea	71.17	28.83	72.08	13.48	9.98
S.Em.±		0.764	0.627	1.492	0.392	0.291
C.D. at 5%		2.21	1.81	4.32	1.13	0.84
Interaction: U × N						
S.Em.±		1.081	0.887	2.110	0.555	0.411
C.D. at 5%		NS	NS	6.26	1.65	1.22
Control v/s Rest						
Treatment mean		72.82	27.18	86.62	15.80	11.70
Control mean		68.99	31.01	88.00	11.11	8.23
S.Em.±		0.156	0.116	0.282	0.121	0.104
C.D. at 5%		0.46	0.34	NS	0.36	0.31
C.V. %		4.18	5.45	7.12	6.20	6.20

Conclusion

The results obtained from the field experiment indicate clear distinctions in the effects of different treatments on growth and yield parameters. Most of the yield and yield attributing parameters were found maximum with application of 100% RDN through urea. While growth and quality parameters were observed highest in 80% RDN. For nano-urea, Application 0.1% nano-urea was found highest for yield and yield attributing parameters. The interaction of 100% RDN + 0.1% nano-urea was better with yield parameters. From the present investigation, it is concluded that application of 100% RDN with 0.1% nano-urea is a successful strategy for enhancing yield of fruits.

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