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Alka Yadav
KNK College of Horticulture, Mandsaur, Madhya Pradesh, India

Jyoti Kanwar
KNK College of Horticulture, Mandsaur, Madhya Pradesh, India

Rajiv Dubey
KNK College of Horticulture, Mandsaur, Madhya Pradesh, India

Megha Upadhyay
KNK College of Horticulture, Mandsaur, Madhya Pradesh, India

Corresponding Author:
Jyoti Kanwar
KNK College of Horticulture, Mandsaur, Madhya Pradesh, India

Effect of foliar application of urea, zinc sulphate and borax on flowering, fruiting and yield of acid lime (*Citrus aurantifolia* Swingle) vari. Kagzi lime under Malwa Plateau conditions

Alka Yadav, Jyoti Kanwar, Rajiv Dubey and Megha Upadhyay

Abstract
Field experiments were conducted during 2016-2017 at K.N.K. College of Hortiuclture, Mandsaur, Madhya Pradesh to find out the to study the effect of urea, zinc sulphate and borax on flowering, fruiting and yield of acid lime. The result revealed that foliar spray of urea 1.5% + borax 0.6% + $ZnSO_4$ 0.5% was found to be the best for maximum increase in plant-height (0.32 m), plant spread in north-south (0.37 m), plant spread in east-west (0.33 m), number of flower per plant (1977.33), fruit set (63.28%), number of fruit per plant (985.00) and reduced fruit drop (36.14%) which ultimately increased the yield of fruit per plant (45.40 kg) compared to other treatments.

Keywords: foliar application, fruiting, acid lime

Introduction
Acid lime is the third important citrus fruit crop in India next to mandarins and sweet oranges. In India, acid lime is grown in a variety of agro-climates comprising from the northern plains and central highlands having hot semi-arid eco-region with black and red soils. Acid lime flowers throughout the years in three distinct seasons known as "bahar" viz, Ambe, Mrig and Hasta bahar. Due to the continuous flowering and heavy crop load on trees, the size of the fruits remains usually very small. Qualitative characters also get affected, resulting into harvest of poor quality and unmarketable fruits. Micronutrients plat a vital role in plants and foliar spray of micronutrient is more successful than soil application. Among the various factors responsible for poor yield and declining health in citrus, deficiency of micronutrients is considered to be the major one (Edward raja, 2009) [7]. Micronutrient can tremendously boost Kagzi lime flowering and fruiting quality (Venu *et al.*, 2014) [16]. Foliar application of the nutrients is obviously an ideal way of evading the problems of nutrient availability. This method is highly helpful for the correction of trace element deficiencies to restore disrupted nutrient supply and to overcome stress factors limiting their availability. Keeping the above facts in mind, a field experiment was conducted at the *Instructional cum Research Fruit Orchard* Department of Fruit Science, K.N.K. College of Horticulture, Mandsaur (M.P.)

Materials and Methods
Field experiment was conducted during 2016-2017 at the *Instructional cum Research Fruit Orchard* Department of Fruit Science, K.N.K. College of Horticulture, Mandsaur (M.P.) to study the effect of urea, zinc sulphate and borax on flowering, fruiting and yield of acid lime on black soils with pH 7.5, O.C (0.94 %), available N (533 kg ha^{-1}), available P (14.9 kg ha^{-1}) and available K (533 kg ha^{-1}). The experiment was laid out in randomized block design with thirteen treatments viz., control, urea (0.5%), urea (1.0%), urea (1.5%), Borax (0.4%), Borax (0.5%), Borax (0.6%), $ZnSO_4$ (0.3%), $ZnSO_4$ (0.4%), $ZnSO_4$ (0.5%), urea (0.5%) + borax (0.4%), $ZnSO_4$ (0.3%), urea (1.0%) + borax (0.5%), $ZnSO_4$ (0.4%) and urea (1.5%) + borax (0.6%), $ZnSO_4$ (0.5%) and replicated three times. Twelve years old uniform trees of acid lime (*Citrus aurantifolia* Swingle) were selected for the study. The recommended management practices were followed uniformly for all the treatments studied.

Results and Discussion
Growth parameters
The data of growth parameters like plant-height increment, plant spread in E-W and N-S direction, leaf area (cm^2) due to the effect of foliar application of urea, zinc sulphate and borax

significantly influenced over the control (Table 1). When applied singly without combination, urea (1.5%) exhibited significantly higher plant height increment (0.24 m), higher plant spread in E-W and N-S direction (0.26 m and 0.30 m, respectively) and leaf area (36.83 cm^2) over all the single treatments. Different level of urea, borax and $ZnSO_4$ when spray in combinations, higher combination i.e. Urea (1.5%) + Borax (0.6%) + $ZnSO_4$ (0.5%) significantly increased plant-height (0.32 m), plant spread in E-W and N-S direction (0.33 m and 0.37 m, respectively) and leaf area (39.97 cm^2) which is followed by the treatment receiving Urea (1.0%) + Borax (0.5%) + $ZnSO_4$. The beneficial effect of nitrogen in increasing the tree growth might be due to the fact that absorbed nitrogen combined with carbohydrates synthesis leads to the formation of nitrogenous compound such as protein, nucleic acids, nucleotides, enzymes and co-enzymes to build up new tissues (Rathore and Chandra, 2003) [12]. Folia application of nitrogen alone and combination with zinc sulphate (0.5%) increased vegetative growth of acid lime trees with respect to plant-height, spread in north to south and east to west directions (Rathore and Chandra, 2003) [12]. The reason for increase in growth due to boron is involved in the carbohydrate metabolism; it directly affects plant growth and indirectly influences the photosynthetic rate (Cakmak and Romheld, 1977) [4] and increases the phenolic compounds which regulate polar auxin transport, the increased auxin activity results in increased tissue growth and development (Gurjar *et al*., 2015) [8].

Zinc increased tree height and leaf size in the treated trees might be due to the active synthesis of tryptophane in the presence of zinc, the precursor of auxin, which in turn causes an increase in the rate of chlorophyll synthesis which ultimately accelerates the photosynthetic activity consequently it increased tissue growth and development (Rawat *et al*., 2010) [13]. Similar results were found by Sajid *et al*., 2010 [15]. The minimum values of growth parameters were found with control.

Reproductive parameters

Reproductive parameters such as number of flowers per plant, fruit set and fruit retention percentage had significantly increased and fruit drop percent is decreased (Table 1). Maximum number of flowers, fruit set, fruit retention and minimum fruit drop were reported with the application of foliar spray of urea 1.5% + borax 0.6% + $ZnSO_4$ 0.5% which was significantly superior than all over treatment. The increase in reproductive parameters may be due to that the nitrogen is an important component of protoplasm and it helped in chlorophyll synthesis which increases in photosynthetic rate resulting more accumulation of carbohydrates leading to flower initiation and profuse flowering. Urea also stimulates the synthesis of endogenous auxins and auxin prevents the abscission and facilitated the ovary to remain attached with the shoot, resulting in lower flower drop and increase retention (Jat and Kacha *et al*., 2014) [9]. Similar results were found by Doraipandian and Shahmugavaelu (1972) [5]. The other possible reason may be urea helped to increase the fruit set either by improving pollen germination or by helping the growth of pollen tubes and thus facilitate in timely fertilization before the stigma loses its receptivity (Doraipandian and Shahmugavelu, 1972) [5]. Boron reduced fruit drop because it play an important role in translocation of carbohydrate, synthesis of auxin and enhancing pollen viability and fertilization (Wet *et al*., 1989) [18]. Boron also required for increase in stigma receptivity and pollen tube growth/extension by formation of boron-sorbitol (sugar-borate) complex that promotes absorption, translocation and metabolism of sugar in pollen and synthesis of pectin material for the cell wall of growing pollen tube and reduction of abscission layer resulting promote flowering (Negi *et al*., 2011) [11]. Zinc is essential for preventing the abscission layer formation and consequently, it involved in synthesis of tryptophan which is the precursor of endogenous auxin and auxin prevents absicission and facilitated the ovary to remain attached with the shoot, resulting in lower flower and fruit drop and increase fruit retention (Jat and Kacha, 2014) [9]. Similar results were found by Yadav *et al*., 2011 [17] and Bhambota *et al*., 1962 [2].

Yield Parameters

The yield parameters such as number of fruits per plant and fruit yield (kg) per plant significantly increased over control. Maximum number of fruits per plant and yield (kg) per plant were found with foliar spray of urea 1.5% + borax 0.6% + $ZnSO_4$ 0.5%) which was significantly superior than all over treatment. The result indicates that the number of fruits per plant was significantly increased due to different levels of urea. The urea has helped in more fruit retention per shoot, which resulted in increasing number of fruits per plant (Syamal *et al*., 2008) [14]. Similar results were found by (Dudi *et al*., 2004) [6]. The cumulative effect of nitrogen on photosynthetic as well metabolic activities has helped to increase the fruit size and fruit weight and thereby increase the fruit yield (Jat and Kacha 2014) [9]. Similar results are also found by Labanauskas *et al*., (1963) [10]. The significant increase in yield by boron application may be accredited to the positive effect of boron on increasing the rates of carbohydrates, cell wall development and RNA metabolism which enhance profuse flowering and fruit setting per shoot resulting increase in yield per plant (Bhatt *et al*., 2012) [3]. The results in line with Rawat *et al*., (2010) [13]. Zinc play important role in auxin synthesis and boron in translocation of start to fruit resulted into better photosynthesis, greater accumulation of starch in fruits. Balance of auxin in plant regulates the fruit drop or retention in plants, which altered the control of fruit drop and increased the total number of fruit per plant (Venu *et al*., 2014) [16]. Similar results is obtained by Banik *et al*., (1997) [1].

Table 1: Reproductive parameters such as number of flowers per plant, fruit set and fruit retention percentage had significantly increased and fruit drop percent is decreased

Treatments	Plant-height increment (m)	Plant-spread increment (m)		Leaf area (cm^2)	No. of flowers/ plant	Fruit set (%)	Fruit drop (%)	No. of fruits/ plant	Fruit yield (kg)/plant
		E-W	N-S						
Control (Water spray)	0.13	0.14	0.15	24.94	1160.00	40.80	57.50	765.00	30.06
Urea (0.5 %)	0.18	0.19	0.24	30.30	1315.33	45.17	52.87	855.00	34.82
Urea (1.0%)	0.22	0.24	0.26	34.00	1396.33	48.65	49.41	880.33	38.05
Urea (1.5%)	0.24	0.26	0.30	36.83	1467.67	50.00	47.91	890.00	39.38
Borax (0.4%)	0.16	0.16	0.17	27.00	1533.44	57.10	44.98	866.67	35.63

Borax (0.5%)	0.18	0.18	0.19	28.50	1663.33	58.47	41.43	892.00	37.96
Borax (0.6%)	0.19	0.19	0.22	29.62	1703.44	58.67	40.97	870.67	38.07
$ZnSO_4$ (0.3%)	0.20	0.20	0.24	30.26	1450.00	49.93	48.00	885.00	37.91
$ZnSO_4$ (0.4%)	0.21	0.22	0.25	32.22	1540.00	52.97	45.41	915.33	40.31
$ZnSO_4$ (0.5%)	0.23	0.23	0.26	33.40	1600.00	54.93	43.94	935.00	41.94
Urea (0.5%) + Borax (0.4%) + $ZnSO_4$ (0.3%)	0.29	0.28	0.32	36.94	1754.44	59.67	40.17	942.00	43.50
Urea (1.0%) + Borax (0.5%) + $ZnSO_4$ (0.4%)	0.31	0.32	0.35	38.23	1860.00	62.03	37.77	960.00	44.75
Urea (1.5%) + Borax (0.6%) + $ZnSO_4$ (0.5%)	0.32	0.33	0.37	39.97	1977.33	63.28	36.14	985.00	45.40
S.Em.±	0.005	0.007	0.007	0.71	3.11	0.59	0.50	14.97	0.32
C.D. at 5%	0.016	0.022	0.021	2.07	9.09	1.73	1.48	43.71	0.93

Conclusion

It can be concluded that foliar spray of urea 1.5% + borax 0.6% + $ZnSO_4$ 0.5% was found to be the best for getting maximum yield of fruit per plant.

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