Research Article

EFFECTS OF FOLIAR APPLICATION OF UREA AND MICRONUTRIENTS ON YIELD AND FRUIT QUALITY OF MANDARIN (*Citrus reticulata* Blanco)

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ABSTRACT

Mandarin (*Citrus reticulata* Blanco) occupies a prominent position in the total fruit industry of Nepal. However, production performance of mandarin has been declined over the last ten years, mainly due to improper nutrient management practices, and has remained as low as 9 t per hectare. This study was done to analyze the effect of foliar application of urea and micronutrients on yield and quality of mandarin. Accordingly, an experiment was done using a Randomized Complete Block design, having four treatments, each replicated four times viz: T_1-control, T_2-urea 2%, T_3-micronutrient (Agromin) 0.4%, and, T_4-urea 2%+micronutrient (Agromin) 0.4%). Spraying of urea, or Agromin alone, or, in combination had a significantly ($p<0.05$) better performance for most of the parameters such as number of fruit, juice content, ascorbic contents, and most of the minerals whereas combined application of urea at 2% and micronutrients (Agromin) at 0.4% had further better performance on these parameters compared to the rest. Thus, two times foliar application of urea alone, and, or in combination with micronutrients could be an effective practice in getting the maximum productivity as well as the fruit quality of mandarin.

Key words: Fruit industry, management, minerals, ascorbic acid

INTRODUCTION

Mandarin (*Citrus reticulata* Blanco) occupies a prominent position in the total fruit industry as this alone contributes 15.02 percent in the total fruit production in Nepal which is expanding rapidly due to its superb eating quality (MOAD, 2016). However, producing performance of mandarin has been declined over the last ten years mainly due to improper nutrient management practices and is remained as low as 9 t per hectare as compared to other developed countries. Nutrient management, especially inadequate nutrition of mandarin orchards is one of the major constraints limiting the productivity. Majority of the orchards in Nepal are deficient in nitrogen and micronutrients (Dhakal & Khanal, 2003; Tripathi & Harding, 2004; Karki et al., 2005; Baral, 2008; Dawadi & Thapa, 2015). Continuous uptake of nutrients from the soil, haphazard application of inorganic fertilizers, and insufficient use of organic manure create a deficiency of micronutrients in the soil (Manandhar & Khanal, 2005). Soil nutrient content is declining over the country from Terai to mountains which is one of the key factors production constraints.

Nutrition management is one of the most important factor in improving the plant growth and yield through increasing photosynthetic efficiency (Ilyas et al., 2015). The placement application of the manure and fertilizer is conventionally predominant practice to supply nutrition which is very tedious, sluggish, costly, and lead to leaching and contamination of underground water. Foliar application of mineral nutrients is an effective and quick method for efficient use of the elements for the higher plants to maximize the productivity. This technique allows the plants to consume nutrients much faster than their uptake from soil by their roots (Ghayekhoo & Sedaghathoor, 2015). Despite some shortcomings, foliar application is regarded as the best method (Marschner & Marschner, 2012). Foliar fertilization is better than conventional soil fertilization under the condition of shortage of nutrient supply, immobilized, and imbalanced (Ladaniya, 2008; Srivastava & Singh, 2009; Gurung et al., 2016).

Foliar application of some nutrients can be 10-20 times more effective than their soil application (Alva et al., 2006). Nitrogen is required to citrus plants to improve yield and quality (Tanany et al., 2011). The spray of B, Cu, Mg, Mn and Zn is more appropriate than their soil application for rapid remedy of their deficiencies (Camberato, 2004). Boron is one of the most important micronutrients, requires to be researched more elaborately to have answer to many evasive issues associated with B-nutrition (Srivastava & Singh, 2009). Application of Cu stabilizes chlorophyll by protecting the chlorophyll-protein lipid complex (Tumolo & Marquez, 2012). Zinc is also involved in photosynthesis and carbohydrate translocation (Tsonev & Lindon, 2012). Manganese is needed in plants for chloroplast formation and photosynthesis, nitrogen metabolism and synthesis of various enzymes (Keuskamp et al., 2015). Fe is necessary maintain vital plant metabolic functions such as chlorophyll synthesis, various enzymatic reactions, respiration and photosynthesis (Ram & Bose, 2000). Foliar application of nutrient has gained importance in recent years to rectify the deficiencies of nutrients (Malik et al., 2000). Under these contexts, this experiment was done to determine the effect of urea and commercial micronutrients as a foliar application on yield and quality parameters of mandarin.

MATERIAL AND METHODS

The experiment was conducted at private orchard of Lamjung district during 2013-2014. The site was located at 1000 masl and the soil texture was sandy loam with a pH of 5.8-6.4. The experiment was laid out using a Randomized Complete Block design, comprised of four treatments, each replicated for four times. Uniform and healthy 15 years of old mandarin trees were selected as treatments, viz: T_1-control (water spray); T_2- urea 2%, T_3- micronutrient (Agromin) 0.4%; and T_4- urea 2%+micronutrient (Agromin) 0.4%. Two times spray as per the treatments was done on 1st May and 1st September of each year. Trees were sprayed in run-off condition with each treatment and controlled tree was sprayed with water. Tween-80 (0.02% v/v) was applied as surfactant with each treatment. The soil samples were collected before and after foliar spray from the zones of maximum feeder roots concentration at a depth of 0-30 cm and at 1 m way from the main trunk. These composite samples were collected in cloth bags, dried under shade, grounded, and sieved through 2 mm sieve for further analysis.

Leaf samples were collected before and after foliar spray. For this, physiologically matured 6-8 months old 40 leaves from 2nd, 3rd, and 4th leaf position of non-fruiting branches representing four directions of the tree were collected on 1st October in each year. The collected leaves were wiped with cotton, immersed in distilled water; air dried in shade, and kept in paper bags and then sent to the laboratory. The collected samples were dried in the oven at 70^0C for 72 hours. Then, samples were grinded and passed through 20-mesh sieve and 1 g sample was for weighed for chemical analysis. Nitrogen was determined using modified Kjeldahl method. Phosphorus was determined by Vanadomolybdate Phosphoric acid yellow colour method, and potassium was determined by acid-peroxide wet digested samples aliquots was used (Wolf, 1982). While, B was extracted dry ashing technique and determined by Spectrophotometer (Jackson, 1973). Fe, Mn, Cu, and Zn were determined with the help of Atomic Absorption Spectrophotometer (Issac & Kerber, 1971).

The fruit were harvested on 15 November each year and physicochemical quality such as number of fruit per plant, fruit weight, juice percentage, Total Soluble Solids (TSS), Titrable Acidity (TA), TSS/acid ratio, and ascorbic acid were determined as procedures mentioned by AOAC (2005). All the data collected during field and laboratory investigation were pooled, tabulated and statistically analysed according to the procedure of Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Number of fruit per plant

The number of the fruit per tree ranged from 302.69-489.55 ($p<0.05$). The highest number of fruit per plant was resulted from spray of urea @ 2% and Agromin @ 0.4% but this was statistically similar ($p>0.05$) with rest of the treatments, except control (Table 1). This increment in number of fruit might be due to the effect of nitrogen which is major constituent of protoplasm and is helpful in chlorophyll synthesis by increasing in photosynthetic activity of trees. The combined positive effect of urea and micronutrients on number of fruit might be due to increase in the rate of biosynthesis of various metabolites and physiological process in the plant system leading to increase rate of fruit growth and efficient uptake of nitrogen and micronutrients through foliage.

Monga et al. (2004) reported that the supplementation of the urea increased the number of fruit significantly in Kinnow mandarin. Similar observation was found by Roussos and Tassis (2011) as well as Malik et al. (2000) who reported foliar application of urea and zinc increased the number of fruit. These findings are in corroboration with the finding of Babu et al. (2007) in Kinnow mandarin, Gill *et al.* (2005) in Kinnow mandarin, and Ram and Bose (2000) in mandarin who reported that mandarin tree with foliar spray of urea and micronutrients increased the number of fruit. Likewise, Mattos et al., (2012) suggested that high doses of N increase the number of fruit and improve fruit size.

Fruit weight

The average fruit weight per plant was varied with the treatments, and ranged from 98.28-106.56 g ($p>0.05$) (Table 1). The treatment with urea at 2% and Agromin at 0.4% was beneficial in improving fruit weight and to retain maximum weight (105.56 g) followed by Agromin sprayed at 0.4% (104.79 g) over the control (98.28 g). These findings are in corroboration with the findings of Monga et al. (2004) in case of Kinnow mandarin, and also to the report of Tariq et al. (2007) in sweet orange as the authors reported that urea and micronutrients sprayed tree had produced significantly heavier fruit. The increase in fruit weight with application of urea plus commercial micronutrients might be due to increase in the rate of biosynthesis of various metabolites and physiological process in the plant system through the efficient uptake of nitrogen and micronutrients.

Table 1. Effect of foliar spray of urea and micronutrients on yield and yield attributing characteristics of mandarin

Treatments	Number of fruit/plant	Fruit yield (kg/plant)	Fruit weight (g)	Fruit diameter (cm)
Control	302.69[b]	29.70[b]	98.28	5.72
Urea 2%	409.09[a]	42.63[a]	104.61	6.01
Agromin 0.4%	417.46[a]	43.72[a]	104.79	6.05
Urea 2% + Agromin 0.4%	489.55[a]	51.82[a]	105.56	6.17
Mean	404.70	41.97	103.31	5.99
$LSD_{0.05}$	122.91	12.80	NS	NS

Fruit yield

Fruit yield was increased with the application of treatments and found in the range of 29.7 kg per tree to 51.82 kg per tree. The treatments were significantly different ($p<0.05$) to the parameter-fruit yield. The highest fruit yield was obtained for the treatment-urea 2% plus Agromin 0.4% (51.82 kg/plant), however, it was statistically similar ($p>0.05$) to the treatment-urea 2%, or Agromin 0.4% (Table 1). These findings are in line with the reports of Babu et al. (2007) in Kinnow mandarin, Ram and Bose (2000) in mandarin as in both cases the fruit yield are reported to be increased by the use of foliar application of urea (2%) along with micronutrients (0.4%). The highest yield in our case might be due to increase in biosynthesis through urea and micronutrient application thereby increase in weight and number of the fruit by reducing the fruit drops, disease and insect pests incidence and physiological disorders (Tariq et.al., 2007).

Fruit diameter

The response of treatments to the fruit diameter was statistically similar ($p>0.05$) (Table 1). However, comparatively the diameter of each fruit was higher for the treatment with urea and Agromin mixture whereas control had the lower diameter of each fruit (Table 1). The increment in diameter of the fruit treated with urea and micronutrients might be due to faster cell division and elongation of the fruit during the growth and development process. This finding related to diameter is in agreement with the findings of Gill et al. (2005) as the authors reported about increase in fruit size and diameter with increased level of nutrients.

Juice content

Table (2) shows that juice percentage was increased significantly in the fruit treated with urea and micronutrients compared to the control ($p<0.05$). The maximum juice content was found in the fruit treated with combined spray of urea with micronutrients (55.77%) whereas this result was statistically similar with the rest of the treatments, except- control (Table 2). Similar results were reported by Tariq et al. (2007) in sweet orange and Babu et al. (2007) in Kinnow mandarin. The maximum juice percentage in mandarin fruit treated with urea in combination with micronutrients might be due to increase in the rate of physiological process in the plant system, thereby increased size of in juice sacs of the fruit.

Table 2. Effect of foliar spray of urea and micronutrients on juice content, TSS, TA and vitamin C content of mandarin

Treatments	Juice content (%)	TSS (^{0}Brix)	TA (%)	Vitamin C (mg/100ml)
Control	49.68[b]	10.37	0.98	32.88[c]
Urea 2%	53.02[ab]	10.44	0.92	34.33[ab]
Agromin 0.4%	53.76[ab]	10.41	0.92	34.77[ab]
Urea 2% + Agromin 0.4%	55.77[a]	10.53	0.89	35.67[a]
Mean	53.06	10.44	0.93	34.41
$LSD_{0.05}$	3.33	NS	NS	1.81

Total soluble solids (TSS)

Total soluble solids (TSS) content of mandarin varied considerably as per the treatments, but statistically remained similar (p>0.05). Here again, the maximum TSS content in fruit was obtained in the trees sprayed with urea in combination with commercial micronutrients (10.53^{0}Brix) followed by urea only (10.44^{0}Brix) where as control resulted in minimum TSS content (10.37^{0}Brix). Several authors who worked with Kinnow mandarin reported that foliar application of nutrients could improve the overall quality of fruit (Monga et al., 2004; Gill et al., 2005; Malik et al., 2000; Babu et al., 2007). The improvement in TSS of fruit due to the fact that urea and micronutrients are helpful in the process of photosynthesis, which ultimately could led to the accumulation of carbohydrates thereby helped in increase of TSS and sugar content in the fruit (Marschner & Marschner, 2012; Ilyas et al., 2015).

Titrable acidity (TA)

The percent titrable acidity (TA) was decreased irrespective of treatments (Table 2). The decreasing trend of TA was varied among the treatments but were statistically similar (p>0.05). The maximum percentage of acidity was found in case of control and the minimum for the treatment with urea alone and in combination with micronutrients (0.89). The decreasing in TA due to the fact that urea and micronutrient may lead in faster dehydration in the fruit physiology (Ram & Bose (2000). Different researchers who worked mandarin have been reported that acidity was decreased with the application of urea alone and in combination with micronutrients in (Babu et al., 2007; Malik et al., 2000; Gurung et al., 2016).

Vitamin C content

Vitamin C content was significantly different (p<0.05) among the treatments (Table 2). The maximum vitamin C (35.67 mg/100 ml) was obtained from the fruit with combined spray of urea (2%) plus micronutrients (0.4%), but this result was statistically similar (p>0.05) to the rest of the treatments, except, control. The higher amount of vitamin C content in the treatment with application of urea and micronutrients could be due to its role in delaying in chlorophyll development causing lesser fruit degradation, and thereby delaying in the fruit maturity (Ghayekhoo & Sedagathoor, 2015).

Leaf nutrient contents

There was significant variation in the nutrient level of the plant among different treatments. The level of nitrogen varied widely from 1.94 to 3.12% indicating that higher level of nitrogen content would have been resulted due the application of urea whereas control plants had lower level of nitrogen content. This finding is in conformity with the findings of Ram and Bose (2000), Mongra et al. (2004), Baral (2008) as the author reported bout the positive contribution of nitrogen to the leaf nitrogen content thereby producing healthy plants. The findings also meet the standard of required nutrient contents of the healthy plants (Srivastava et al., 2007; AOAC, 2005; & SPAC, 1998). Mattos et al. (2012) suggested that high doses of N increase the number of fruit and fruit size on the tree.

Likewise, P content was higher in plant treated with urea 2% (0.16%) and urea 2% plus Agromin 0.4% (0.25%) while untreated plant had lower level of P content (0.08%). K content was optimum (1.01%) with urea 2% plus Agromin 0.4% where control plant showed the low level (0.48%). P and K content in the leaves were widely varied irrespective to treatments but this result matches closely with the reports of other researchers (Baral, 2008; Ram & Bose, 2000; Monga et al., 2004).

Table 3. Effect of foliar spray of urea and micronutrients on N, P, K and micronutrient content in mandarin leaves

Treatments	N (%)	P (%)	K (%)	Zn (ppm)	Bo (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)
Control	1.94^{b}	0.08^{c}	0.47^{c}	13.63^{b}	10.51^{b}	2.4^{b}	71.31^{c}	8.61^{c}
Urea 2%	2.97^{a}	0.16^{b}	0.72^{b}	26.38^{a}	18.11^{ab}	5.64^{b}	164.63^{b}	18.69^{bc}
Agromin 0.4%	2.62^{a}	0.16^{b}	0.75^{b}	28.78^{a}	18.23^{ab}	19.43^{a}	168.39^{b}	28.57^{ab}
Urea 2% + Agromin 0.4%	3.12^{a}	0.25^{a}	1.04^{a}	29.05^{a}	24.59^{a}	18.42^{a}	213.25^{a}	39.93^{a}
Mean	2.61	0.16	0.75	24.46	17.86	11.57	154.4	23.95
$LSD_{0.05}$	0.13	0.03	0.17	7.38	13.2	8.18	45.19	10.17

Foliar application of urea and micronutrient had positive effect on other plant leaf nutrient content. Zn, Bo, Cu, Fe, and Mn content were significantly varied among the treatments (Table 3). The level of Zn was higher in the plant sprayed with urea 2% (26.38 ppm), Agromin 0.4% (28.78 ppm), and in combination (29.05 ppm) and control had low level (13.63 ppm). Boron was found in optimum level in all the treatments and ranged from 10.51 to 24.59 ppm. Likewise, the status of Cu was optimum to high range in all treatments (Table 3). Fe content was statistically significant among the treatments which ranged from 71.31 to 213.25 ppm, and found maximum in urea and Agromin spray (213.25 ppm). The status of Mn was below the optimum range in all the treatments, however, the maximum level of Mn was observed in the plant with urea 2% plus Agromin 0.4% application where as control had the deficient level Mn (8.61 ppm).

Results showed that foliar spray of micronutrients significantly increased the micronutrients concentration in mandarin leaves (Table 3). The increment in the leaf nutrient was might be due to interaction effect of Zn, B, Cu, Mn, and Fe. Several authors have been reported that Zn increased Carbonic anhydrase enzymes, B involved in pollen set, Cu supplied the electrons in photochemical system, Fe strengthened the cell wall composition, Mn stabilized the photosynthesis in mandarin (Srivastava et al*.,* 2007; Tariq et al., 2007; Kaur et al*.,* 2015; & Ilyas et al., 2015). This positive interaction among the micronutrients alone and with urea significantly increased the number of fruit per plant, fruit yield and quality of mandarin as observed by Gurung et al. (2016); Ghayekhloo and Sedaghathoor (2015).

CONCLUSION

The findings of this study clearly revealed that two times foliar application of urea alone, and, or in combination with micronutrients at fruit development stage (May and September) could be an effective practice in getting the maximum productivity as well as the fruit quality of mandarin.

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