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Foliar Fertilization for Enhancing Yield and Fruit Quality of Apple under Rain-Fed Conditions of Mid-Himalayas

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ABSTRACT

A participatory experiment was conducted to assess the effect of foliar application of urea and Agromin on apple. Agromin is a commercial formulation of micronutrients containing mineral elements comprising of optimum proportion of zinc, copper, manganese, boron, molybdenum and magnesium. The experiment was conducted at three different sites at altitudes between 1800 to 2200 m above mean sea level. Thirteen to fifteen years old, uniform trees of cultivar Royal Delicious were applied with treatments *viz.* Urea @ 0.5% (T_1), Agromin @ 0.25% (T_2), Urea @ 0.5% + Agromin @ 0.25% (T_3), Urea @ 1.0% (T_4) and Urea @ 1.0% + Agromin @ 0.25% (T_5). Urea and Agromin sprays were done between tight to pink cluster stage of growth. These treatments were compared to control plants which were applied the recommended doses of Nitrogen. Results showed that vegetative growth was significantly influenced by the application of urea and agromin. Application of Urea @1.0% + Agromin 0.5% (T_5) resulted in highest plant height (29.17 cm), girth (1.10mm), shoot extension growth (45.25cm) and tree spread (14.23 cm) which was at par with treatment T_4. Maximum fruit length (6.71cm), diameter (5.57cm), fruit weight (88.41g) and total yield per plant were recorded in the treatment T_5 (Urea @1.0% + Agromin 0.5%) followed by the treatments T_3(Urea @0.5% + Agromin @ 0.25%) and T_1 (Urea 0.5 %). The highest benefit: cost ratio (2.80) was obtained in the treatment T_5 (Urea 1.0 % + Agromin 0.25 %). The lowest B:C ratio (2.45) was observed in Control due to the lowest number of large and medium grade fruits.

Key Words: Apple, Fertilizer, Foliar, Fruit quality, Mid-Himalayas, Rain-Fed, Yield.

INTRODUCTION

Apple (*Malus domestica*) belonging to family Rosaceae is the leading temperate fruit crop of North-Western Himalayan states of India. In Himachal Pradesh, apple was grown on an area of 1.11 Lac haand producing 7.77 Lac MTcrop during the year 2015-16 (Anonymous, 2017). The average productivity (7.02 MT/ha) is much lower than the potential yield of the crop due to several reasons. One of the major constraints is that most of the apple plantations are grown over hilly slopes subjected to huge loss of productive soil due to soil erosion. This reduces the soil fertility and subsequently the crop productivity. In addition, modern fruit cultivation practices like high density plantation, obtaining higher yields from relatively young plants and obtaining high quality fruits requires more attention to plant nutrition (Bright, 2005).

Nitrogen is a major element, required by all plants. Adequate nitrogen is essential for tree growth, leaf cover, blossom formation, fruit set and fruit size, all of which combine to determine crop yield (Bright, 2005). Many workers have shown that fertilization of fruit trees with nitrogen fertilizer has increased fruit set, vegetative growth and yield (Klein *et al,* 2006). Although, micronutrient elements are needed in relatively very small quantities for adequate plant growth and production, their deficiency may cause great disturbance in the physiological and metabolic processes involved in

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the plant (Babaeian *et al*, 2011).Nitrogen and boron in addition to soil application appears to have a great effect on growth, yield and quality of fruits. The application of micronutrient fertilizer in the cultivation zone may not meet the crop requirement for root growth and nutrient use.

Foliar fertilization is a common practice to supply crops with mineral nutrients, especially under conditions of limited soil nutrient availability or in the case of acute deficiency. Calcium and N are the most important and commonly used elements applied through foliar applications in tree fruit, including apple (Fallahi and Eichert, 2013). Foliar fertilization has advantage of low application rates, uniform distribution of fertilizer materials, easiest method of application and quick responses to applied nutrients (Khayyat*et al*, 2007). Many investigations studied the effect of spraying macro and micronutrients on growth, yield and fruit quality such as nitrogen, phosphorus, potassium and magnesium (Gobara, 1998). However, boron (Hanson, 1991); manganese (El-Shazly, 1999) were highly effective in improving, nutritional status yield and quality of different pear and apple trees. The present experiment was therefore conducted to study the effect of N and micronutrient sprays on growth, yield and fruit quality of apple.

MATERIALS AND METHODS

The experiment was conducted at three different sites at altitudes between 1800 to 2200 m above mean sea level. Thirteen to fifteen years old, uniform trees of cultivar Royal Delicious were applied with treatments *viz.*Urea @ 0.5% (T_1), Agromin @ 0.25% (T_2), Urea @ 0.5% + Agromin @ 0.25% (T_3), Urea @ 1.0% (T_4) and Urea @ 1.0% + Agromin @ 0.25% (T_5). Urea and Agromin sprays were done between tight to pink cluster stage of growth. These treatments were compared to control plants which were applied the recommended doses of Nitrogen. All the plants under treatments were also applied with the recommended dose of Nitrogen as soil application. Each treatment was replicated four times as per randomized block design.

Observations were recorded on fruit length, diameter and weight on the farmers fields by randomly selecting ten fruits from each plant. Ten shoots were randomly selected around the periphery of the tree and their extension growth was measured before pruning and the results were expressed as cm shoot extension growth. Fruit set was recorded three weeks after petal fall and per cent fruit set was calculated by following formula given by Westwood (1993).

Fruit set (%) = Number of fruit set/ Number of flowers cluster × 100.

The yield of fruits in kg/tree under different treatments was determined on the basis of total weight of fruits harvested from the tree under each treatment.

Fruit yield was recorded by removal of crop load during harvesting season as kg/tree based on 20 kg standard apple box and later converted in to q/ha. The weight of fruit was taken with the help of a top pan balance. The unit sample consisted of ten fruits and the results were expressed as weight in grams per fruit.

Fruit diameter was recorded with the help of vernier caliper.

The fruit firmness was measured with the help of pressure tester and expressed as kg/cm^2.

Total soluble solids were determined using a hand refractometer, percentage of titratable acidity in fruit juice was determined according to AOAC (1995), and total sugar in the fruit pulp was determined by phenol sulphuric method according to (Dubois *et al,* 1956). Data of both the years were pooled and average mean is given in the Tables. Grade wise average selling price was used to calculate gross income and B:C ratio.

RESULTS AND DISCUSSION

Results obtained from the experiment showed that vegetative growth was significantly influenced by the application of Urea and Agromin. Application of Urea @1.0% + Agromin 0.5% (T_5) resulted in

Table 1. Effect of foliar nutrition on vegetative growth of apple.

Treatment	Increase in Plant height (cm)	Increase in Plant Girth (mm)	Extension growth (cm)	Tree Spread
T_1	24.92	0.94	46.54	28.63
T_2	23.08	0.99	45.87	26.92
T_3	26.08	0.90	41.40	30.21
T_4	29.17	1.10	45.25	32.18
T_5	28.58	0.98	49.03	31.60
T_6	21.25	0.81	38.20	32.88
CD ($P\leq_{0.05}$)	1.07	0.08	8.27	6.97

Table 2. Effect of foliar fertilization on fruit size and yield of apple.

Treatment	Flowering intensity (flower clusters/m shoot)	Fruit set (%)	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Total yield (q/ ha)
T_1	25.07	31.74(34.29)	6.45	5.45	79.36	80.25
T_2	23.72	31.42(34.09)	6.40	5.43	77.58	78.64
T_3	26.41	37.87(37.98)	6.51	5.42	83.11	82.33
T_4	24.92	39.25(38.79)	6.58	5.50	84.96	84.25
T_5	27.67	40.96(39.79)	6.71	5.57	88.41	87.15
T_6 (Control)	21.56	29.58(30.22)	6.20	5.14	73.50	71.1
CD ($P\leq_{0.05}$)	2.08	3.15	0.17	0.11	6.23	5.45

highest plant height (29.17 cm), girth (1.10mm), shoot extension growth (45.25cm) and tree spread (14.23 cm) which was at par with treatment T_4. Dong *et al* (2005) reported positive relationship between spring growth and Nitrogen content (Table I).

The highest (27.67 flower clusters/m shoot) flowering intensity and fruit set (39.79 (flower clusters/m shoot)) in apple plants were obtained in the combination of Urea @1.0% + Agromin 0.5% (T_5) whereas the lowest (21.56 and 30.72 (flower clusters/m shoot), respectively) values for these traits were obtained in control. Maximum fruit length (6.71cm), diameter (5.57cm), fruit weight (88.41g) and total yield per plant were recorded in the treatment T_5 which was closely followed by the treatments $T_3$and T_1.

The beneficial effects of micronutrient sprays in apple on enhancing fruit set and yield especially those containing B and Zn have been elucidated by number of workers (Sharma, 2016 andKumar *et al*,2003). Kumar *et al,*(2003) reported highest fruit set and yield in Starking Delicious apple with foliar application of Urea @ 0.05% + Boric acid @ 0.1%. Roy *et al*(2006), reported the role of boron in pollen germination and elongation of pollen tube growth which resulted in increased fruit set and yield in deciduous fruits.

Fruit quality

Fruit quality parameters were also affected significantly by various treatments (Table 3).

Highest TSS (13.26°B) was observed in the treatment T_1 and its lowest value (12.10°B) in the treatment T_1. Maximum titratable acidity (0.3%) was observed in treatment $T_4$and lowest (0.19%) in control. The application of urea was found to reduce TSS of the fruits. Highest total sugar

Table 3. Effect of foliar nutrition on fruit quality in apple.

Treatment	TSS	Titratable acidity	Total sugars
T_1	16.13	0.32	7.27
T_2	16.94	0.36	7.29
T_3	17.22	0.36	7.42
T_4	17.85	0.39	7.86
T_5	18.16	0.43	7.89
T_6 (Control)	16.33	0.44	7.51
$CD_{0.05}$	0.78	0.06	0.22

content (7.86%) was also recorded in plants which received application of Agromin @ 0.25% (T_2). Foliar fertilization with urea was found to reduce fruit quality of apple and decrease TSS content in a study conducted by Amiri*et al*, (2008). Similar observation was also recorded by Nava *et al*(2008) who reported negative impact of nitrogenous fertilizers application on fruit color, firmness and TSS content of apple fruits.

CONCLUSION

The fruits of each treatment were graded into four grades viz. large, medium, small and others to find out the cost benefit ratio of each treatment. The grade wise average market price of fruits was used to obtain net returns and profit. It was observed that treatment combinations having Agromin increased the proportion of large and medium sized fruits thereby increasing the net returns over Urea application alone and Control. The highest benefit: cost ratio (2.80) was obtained in the treatment T_5(Urea 1.0 % +Agromin 0.25 %). The lowest B:C ratio (2.45) was observed in Control due to the lowest number of large and medium grade fruits.

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Table 4. Grade-wise fruit yield, income and B:C ration of apple as

Treatment	Yield proportion by grade (kg/100 Kg offruit)				Net returns (Rs)	B:C ratio
	Large	Medium	Small	Others		
T_1	12	26	34	28	2,60,000	1:2.48
T_2	15	25	31	29	2,70,000	1:2.57
T_3	22	29	25	24	2,94,000	1:2.67
T_4	20	30	33	17	2,84,000	1:2.58
T_5	30	25	32	13	3,09,450	1:2.80
T_6 Soil application	10	24	33	33	2,45,000	1:2.45

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