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Effect of foliar application of micronutrients on physico-chemical attributes of phalsa (*Grewia subinaequalis* D.C.)

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Abstract
The present investigation entitled "Effect of foliar application of micronutrients on growth and yield of phalsa (*Grewia subinaequalis* D.C.) Fruits" was carried out at Main Experimental Station, Department of Fruit Science, Acharya Narendra Deva University of Agriculture and Technology Kumarganj Ayodhya (U.P) during year 2017-18 to investigate the response of foliar application of micronutrients on the physio-chemical quality of phalsa fruits. Eight effective treatments of foliar application of micro-nutrient zinc shulphate 0.4%, Borax 0.2%, and Iron 0.4% as individual and in combination were incorporated with three replication as T_1 (Control), T_2 ($ZnSO_4$ 0.4%), T_3 Borax 0.2%, T_4 ($FeSO_4$ 0.4%), T_5 ($ZnSO_4$ 0.4% + Borax 0.2%), T_6 (ZnSO4 (0.4%) + FeSO4 (0.4%), T_7 (Borax 0.2% + $FeSO_4$ 0.4%), T_8 ($ZnSO_4$ 0.4% + Borax 0.2% + $FeSO_4$ 0.4%). The foliar spraying of the micronutrients on the plants were done twice first at just before bloom and second just after fruit set. Fruit quality in terms of fruit weight, dimensions, pulp-stone ratio, titrable acidity, ascorbic acid, total soluble solids, reducing sugars, non-reducing sugar and total sugar were recorded and statistically analysed as per Randomised block design (R.B.D) at $p< 0.05$. The observations recorded during the investigation revealed that phalsa plants fed with micronutrients significantly improve the quality of phalsa fruits. Maximum fruit weight of 50 fruits (48.59 g), Fruit dimensions (length and breadth 1.24 cm and 1.16 cm respectively), pulp-stone ratio (1.22), ascorbic acid (38.56mg/100g pulp), Total soluble solids (22.63 ^{0}Brix), Reducing sugar (15.77%), Non-reducing sugar (3.59%), Total sugar (19.36%) whereas minimum titrable acidity (1.77%) were recorded in fruits of plants foliar fed with zinc sulphate 0.4% + Borax 0.2% + Ferrous sulphate 0.4% (T_8) which was significantly superior over the other treatments.

Keywords: Phalsa, micronutrients, borax, zinc sulphate, ferrous sulphate

Introduction
Phalsa (*Grewia subinaequalis* D.C. *syns. Grewia Asiatica Mast.*) is a shrub of Indian origin (Chundawat and Singh 1980) [4]. Phalsa belongs to the family Tiliaceae. There are around 140 species in genus *Grewia.* The important ones are *Grewia glabra, Grewia micrococas, Grewia optiva, Grewia tilifolia,* and *Grewia belosa.* It was introduced into the Philippines before 1914 and naturalized in Australia. Phalsa is known by different names in different Indian languages such as Dhamani in Bengali, Phalsa in Punjabi, Shukri in Hindi, Mirgi Chara and phrasakoli in Oriya, Tadasala in Kannada etc. (Sastri 1956) [14]. Phalsa is a crop of arid and semi-arid regions because of its hardy nature and capacity to tolerate high temperatures. It is commercially grown in Punjab, Haryana, Uttar Pradesh and Madhya Pradesh, Maharashtra, Gujarat, Andhra Pradesh, Bihar and West Bengal.

Phalsa is a large, scraggly shrub or small tree to 4.5m (if unpruned). It has long, slender, drooping branches, the young branchlets densely coated with hairs. The leaves are alternate deciduous, ovate, pointed at the apex, coarsely toothed with whitish bloom on the underside. Phalsa bears small yellow flowers born in dense cymes on the leaf axils during onset of spring i.e. February. Phalsa fruits are fleshy fibrous drupe bears on peduncles produced in clusters in the axils of leaves on the young shoots are spherical (1-1.6cm) in shape, the skin turns from green to purplish-red and finally dark purple with whitish blush (Tripathi 2010 [18] and Gupta 2006) [5]. The fruits ripen during the second fortnight of April and continue to middle of June. The flavor is pleasantly acidic. Large fruits have two hemispherical hard seeds. Small fruits are single-seeded. the fruits are very perishable and considered suitable only for local marketing (Panda 2002, Anand 1960) [12, 2] In northern India, it sheds its leaves during winter and remains in a dormant condition, which facilitates it to make capable of withstanding the frost and other cataclysmic conditions of climate.

It is one of the hardiest fruit crops with regard to the susceptibility of insect pest and diseases.

Phalsa is not very exacting in its soil requirements; thus it can be grown on a wide range of soils, even on moderately alkaline soils. However, the best results are obtained in well-drained, loamy soils. The soils where other fruit trees fail to grow, it can be grown successfully. The plants can tolerate temperatures as high as 45ºC and freezing temperatures for a few days. The high temperature helps in the ripening of the fruits. Phalsa is a seed propagated crop and starts fruiting three year after planting. It can be grown as a filler crop, intercrop (with mango, aonla, ber, bael).

Phalsa has high nutritional values, low in calories and fat and high in vitamins, fibers and minerals containing iron, vitamin 'A', 'C' and phosphorus, ripe fruit contains 50-60% Juice, 10-11% sugars and 2-2.5% acid (Yadav 1999) [22]. The fruits are used for making excellent juice and squash. It is also used as table purpose by children. Its fruits possess high medicinal properties. Its ripe berries exert cooling effect, cure inflammation, heart diseases, blood disorders, fever and constipation. It also has tonic and aphrodisiac properties. Phalsa fruits contain 80.80% moisture, 1.30% protein, 0.90% fat, 14.7% carbohydrate, iron 3.1 mg/ 100g pulp and ascorbic acid 22.0 mg/ 100g pulp (Zia -Ul- Haq *et al.* 2013) [21].

Phalsa needs frequent application of micronutrients which help in achieving higher yield and better-quality fruit crops. Micronutrients can be applied to plants by soil and foliar application. Foliar application of micronutrients is more effective than soil application as it can easily absorbed by leaf surface.

Zinc is one of the eight essential trace elements or micronutrients for the normal healthy growth and reproduction of crop plants (Keram *et al*., 2014) [6]. It helps in production of RNA polymerase enzymes and synthesis of IAA. Zn is necessary for water uptake. Availability of zinc is reduced in alkaline soil; therefore, foliar application of Zn can be useful under such condition. Boron is essential for translocation of sugar. Its primary role concerned with Calcium metabolism and keeps calcium in soluble form within the cell and acts as regulator of K/Ca ratio. It is involved in reproduction of plants and germination of pollen grains. Iron acts as activator in synthesis of chlorophyll, it is absorbed by plant in Fe^{2+} form and work as oxygen carrier. Plant of phalsa is highly sensitive to iron deficiency. Zn and Fe are beneficial for juice content and berry size of phalsa. The beneficial effect of zinc sulphate, ferrous sulphate has been reported by Singh *et al.* (1981) [17] and Wali *et al.* (2005) [19].

The foliar application of Micronutrients (Zinc, Boron, Iron) enhances the Physiochemical properties of Phalsa fruit. Therefore, the investigation entitled "Studies on the effect of foliar application of micronutrients on physiochemical characters of Phalsa (*Grewia subinaequalis* D.C.)" fruits was carried out to evaluate the response of different micronutrients on the quality of phalsa fruits

Material and Methods

During the years 2017-2018 the research trial was conducted at Main Experimental station of Fruit Science, Acharya Narendra Deva University of Agriculture & Technology-Kumarganj Ayodhya on 20year phalsa plants which were pruned in January. Geographically, It is situated at 26.47º North latitude, 82.12º East longitude and altitude of 113 meter from sea level. The site is located in typical saline alkaline belt of Indo-gangetic plains of eastern Uttar Pradesh.

The experiment was laid out in Randomized Block Design with three replication in the month of January, 2018 with the allocation of eight treatment of micronutrients (Zn, Boron, Iron) as T_1 (Control), T_2 ($ZnSO_4$ 0.4%), T_3 Borax 0.2%, T_4 ($FeSO_4$ 0.4%), T_5 ($ZnSO_4$ 0.4% + Borax 0.2%), T_6 ZnSO4 (0.4%) + FeSO4 (0.4%), T_7 (Borax 0.2% + $FeSO_4$ 0.4%), T_8 ($ZnSO_4$ 0.4% + Borax 0.2% + $FeSO_4$ 0.4%). The foliar application of the micronutrients was done twice time. First spraying in 2nd week of March at pre-bloom stage and 2nd spraying just after the fruit set in April. The observations were recorded for Fruit size (length and breadth), weight of fifty fruits, pulp stone ratio, total soluble solids, Titrable acidity, Ascorbic acid, Reducing Sugars, Non-Reducing Sugar, Total Sugars.

Fruit size was measured with the help of vernier callipers, weight was measured on the digital balance, pulp stone ratio was calculated by dividing the pulp weight with the seed weight. The total soluble solids of the fruits were measured using an Erma Hand Refractometer (Tokyo, Japan) with a range of 0-32^0 Brix and adjusted at 20^0 degrees Celsius. The value was read against the light by crushing a small piece of fruit and placing it on the refractometer's prism. The AOAC method was used to compute ascorbic acid and titrable acidity (2000) [3]. The sugar % was calculated using the 'Fehling solution method,' which was expressed as a percentage.

The data obtained from the experiment was calculated and statistically analysed using Panse and Shukhatme's (1985) [13] approach, with the results assessed at a 5% level of significance.

Results and Discussion

The results obtained during the investigation revealed that foliar application of different micronutrient as individual and combination has significantly influenced the quality of phalsa fruits. Fruit length of phalsa was significantly increased with foliar feeding of different micronutrients. Maximum fruit length (1.24 cm) was recorded in the treatment T_8 (Zinc sulphate 0.4% + Borax 0.2% + Ferrous sulphate 0.4%) however, treatment T_7 (Borax 0.2% + $FeSO_4$ 0.4%), T_4 ($FeSO_4$ 0.4%), T_3(Borax 0.2%) and T_2 (ZnSO4 0.4%) were found at par. The minimum value (1.00 cm) of fruit length was noticed in control (T_1 - Water spray). Fruit breadth was also significantly influenced with the foliar application of micronutrients. The maximum fruit breadth (1.16cm) was recorded in the fruits treated with the T_8 (Zinc sulphate 0.4% + Borax 0.2% + Ferrous sulphate 0.4%) followed by treatment T_7 (Borax 0.2% + $FeSO_4$ 0.4%) which was found at par with the treatment T_4 ($FeSO_4$ 0.4%), T_3 (Borax 0.2%), T_2 ($ZnSO_4$ 0.4%). The minimum breadth (0.94cm) was recorded in control (T_1 - Water spray). The reasons for increase fruit size due to foliar spraying of micro nutrients might be attributed to efficient absorption and accumulation of metabolites in initial stage of developing fruit. Spraying of zinc sulphate which provide zinc to plant, might regulated the cell wall permeability, thereby allowing more mobilization of water in fruit attributing to larger size. These results are in close conformity with the findings of various work in phalsa Singh *et al.* (2001) [16] obtained maximum fruit size of aonla with the foliar application of Zinc sulphate (0.5%) + Borax (0.2%) + Copper sulphate (0.4%) and Mishra *et al.* (2017) [11] also obtained maximum fruit size in phalsa with the foliar application of Zinc sulphate (0.25%) + Manganese sulphate (0.5%) + Copper sulphate (0.4%).

The micronutrients also have significant effect on the fruit weight. Maximum fruit weight of 50 fruits (48.59 g) was recorded in fruits treated with treatment T_8 (Zinc sulphate 0.4% + Borax 0.2% + Ferrous sulphate 0.4%) which was found superior over the rest of treatments. The pulp-stone ratio of the phalsa fruits significantly varies with the foliar application of different micronutrients. Fruits treated with treatment T_8 (Zinc sulphate 0.4% + Borax 0.2% + Ferrous sulphate 0.4%) have highest pulp-stone ratio. The fruits treated with treatment T_8 was found significantly superior over all the treatments. The least pulp-stone value was recorded in the fruits of control treatment (1.07) The increase in fruit weight and pulp stone ratio of fruit by application of different combination of micronutrients might be due to rapid cell division, cell elongation, translocation of sugar and higher pulp ratio. The increase in fruit weight by zinc spray may be due to the accumulation of more food material in phalsa fruits. However, borax has significant role in the formation of hormone, it helps in activation of superfluous growth hormone by formation of complex compound. Zinc and Boron proved better to improve fruit weight and pulp/stone ratio in litchi by Kumar *et al*. (2004) [7] reported significant increment in fruit weight with foliar spray of Zinc (0.5%, 1.0%), boron (0.4%, 0.6%) and copper (0.5%,0.1%) and Jitendra *et al*. (2017) also mentioned the beneficial effect of Boron (0.4%), Ferrous sulphate (0.4%) and zinc sulphate (0.4%) in phalsa.

The foliar application of different micronutrients significantly improves the chemical attributes of fruits except the acidity which was found not significant response of micronutrients however the maximum value of acidity (2.26%) recorded in control treatment whereas the minimum titrable acidity least value of acidity (1.78%) in the fruits treated with T_8 (Zinc sulphate 0.4% + Borax 0.2% + Ferrous sulphate 0.4%)

The ascorbic acid content in phalsa fruits was significantly influenced with the foliar application of micronutrients. It ranges from 34.57 mg/100g pulp in control to 38.56mg/100g pulp in the treatment T_8 (Zinc sulphate 0.4% + Borax 0.2% + Ferrous sulphate 0.4%) which was found at par with T_6 ($ZnSO_4$ 0.4% + $FeSO_4$ 0.4%), T_4 ($FeSO_4$ 0.4%), T_3 (Borax 0.2%). The increase in ascorbic acid content was due to zinc, Boron which activates synthesis of ascorbic acid and photosynthates. The findings are closely confirmed by Kumar *et al*. (2014) [8] noted highest ascorbic acid with the combined spray of GA_3 20ppm + NAA 50ppm + $ZnSO_4$ (0.4%) + Urea (2%) in phalsa fruit and also Singh *et al*. (2015) [16] noted maximum ascorbic acid content of phalsa fruit with foliar spray of $ZnSO_4$ 0.4%.

The data presented in table-2 revealed that foliar feeding of micronutrients significantly improves the level of Total soluble solids and Sugars. The maximum total soluble solids (22.63 ^{0}Brix) was recorded in the fruits treated with T_8 (Zinc sulphate 0.4% + Borax 0.2% + Ferrous sulphate 0.4%) which was followed by T_7 (Borax 0.2% + $FeSO_4$ 0.4%) and both treatments showed superior results over the other treatments. The minimum TSS (16.34 ^{0} Brix) was recorded in the control (T_1). The increase in the TSS content of fruit may be explained by the fact that zinc and iron are helpful in photosynthesis which ultimately lead to the accumulation of carbohydrates which helps in increasing TSS content of fruits. The present result is enclosed conformity with the finding of Mishra *et al*. (2003) [10] obtained maximum total soluble solids with foliar spray of $ZnSO_4$ (0.5%), $FeSO_4$ (0.4%) and boric acid (0.2%), in kinnow mandarin and Yadav *et al*. (2004) [20] also obtained maximum total soluble solids with spray of $ZnSO_4$ of 0.2, 0.4, 0.6 and 0.8 per cent, $FeSO_4$ at 0.2, 0.4, 0.6 and 0.8 per in strawberry cv. Chandler.

Reducing sugars significantly increased with the application of micronutrients in combination. The maximum reducing sugars (15.77%) was noted in the treatment T_8 which was followed by T_5 ($ZnSO_4$ 0.4% + Borax 0.2%) and Treatment T_2 ($ZnSO_4$ 0.4%), T_5 ($ZnSO_4$ 0.4% + Borax 0.2%) and T_7 (Borax 0.2% + $FeSO_4$ 0.4%) was found nonsignificant with each other. The least reducing sugars (12.90%) was recorded in control T_1. The Non-reducing sugar (3.59%) was recorded maximum in fruits treated with T_8 (Zinc sulphate 0.4% + Borax 0.2% + Ferrous sulphate 0.4%) which was followed by T_7 (Borax 0.2% + $FeSO_4$ 0.4%) both of them were found at par and significantly superior over other treatments. Treatment T_2 (ZnSO4 0.4%), T_3 (Borax 0.2%), T_4 ($FeSO_4$ 0.4%), T_5 ($ZnSO_4$ 0.4% + Borax 0.2%) and T_6 ($ZnSO_4$ 0.4% + $FeSO_4$ 0.4%) were recorded nonsignificant with each other. Least values were noted in control (T_1). The findings noted for total sugars revealed that the level of total sugars was significantly varies with the application of micronutrients; the maximum total sugar percentage was observed in fruit treated with treatment T_8 (Zinc sulphate 0.4% + Borax 0.2% + Ferrous sulphate 0.4%) which was followed by T_5 ($ZnSO_4$ 0.4% + Borax 0.2%) these were found at par with each other The minimum value of total sugar noted in fruits of control (T_1). The significant increase in sugar contents might be due to translocation of more sugar to the fruits. It has been reported that there is a greater conversion of starch in sugar in presence of Boron. It also has a function of accumulation of carbohydrates in fruits as a result of increased supply of nitrogen, phosphorus, zinc, boron, iron. Similar findings also reported by Mahendra *et al*. (2007) [9] obtained maximum total sugar, with the combined spray of $ZnSO_4$ 0.4% + 2% urea + potassium sulphate (0.2%) in phalsa fruit and Abhijit *et al*. (2018) [1] in aonla fruit.

Table 1: Effect of foliar application of micronutrients on physio-chemical attributes of phalsa

S. No.	treatment	Fruit length (cm)	Fruit breadth (cm)	Weight of 50 fruits	Pulp/ stone ratio	Acidity (%)	Ascorbic acid (mg/100g pulp)
T_1	Control	1.00±0.037d	0.94±0.015d	39.86±1.432b	1.07±0.020c	2.26±0.239	34.57±0.601d
T_2	ZnSO4 0.4%	1.19±0.058abc	1.11±0.010abc	41.44±1.205b	1.15±0.006b	1.94±0.096	35.23±0.514d
T_3	Borax 0.2%	1.15±0.027abc	1.02±0.038cd	40.12±0.860b	1.14±0.019b	2.38±0.423	37.60±0.478a
T_4	$FeSO_4$ 0.4%	1.17±0.019abc	1.07±0.060bc	43.85±1.057b	1.15±0.015b	2.60±0.276	37.14±0.494ab
T_5	$ZnSO_4$ 0.4% + Borax 0.2%	1.15±0.019bc	1.02±0.040cd	41.81±1.055b	1.12±0.015b	2.03±0.130	35.39±0.577cd
T_6	$ZnSO_4$ 0.4% + $FeSO_4$ 0.4%	1.10±0.058c	1.03±0.058cd	40.85±0.280b	1.13±0.030b	2.41±0.057	36.97±0.393abc
T_7	Borax 0.2% + $FeSO_4$ 0.4%	1.20±0.012ab	1.13±0.010ab	42.68±1.531b	1.16±0.019b	2.57±0.523	35.51±0.692bcd
T_8	$ZnSO_4$ 0.4% + Borax 0.2% + $FeSO_4$ 0.4%	1.24±0.007a	1.16±0.009a	48.59±2.869a	1.22±0.012a	1.78±0.149	38.56±0.595a
	S.Em±	0.03	0.03	1.46	0.02	0.22	0.55
	C. D. (P=0.05)	0.09	0.10	6.0	0.06	NS	1.66

Table 2: Effect of foliar application of micronutrients on TSS and Sugar content in phalsa

S. No.	Treatment	Total soluble solids (^{0} Brix)	Reducing Sugars (%)	Non- Reducing Sugar (%)	Total Sugars (%)
T_1	Control	16.36±0.358c	12.90±0.265c	2.43±0.012c	15.33±0.253c
T_2	ZnSO4 0.4%	20.40±0.053b	14.97±0.042ab	3.27±0.074b	18.24±0.062b
T_3	Borax 0.2%	19.97±0.374b	14.78±0.568b	3.28±0.171b	18.06±0.737b
T_4	$FeSO_4$ 0.4%	20.00±0.052b	14.21±0.064b	3.10±0.078b	17.31±0.140b
T_5	$ZnSO_4$ 0.4% + Borax 0.2%	20.73±0.453b	15.00±0.517ab	3.30±0.065b	18.31±0.581ab
T_6	$ZnSO_4$ 0.4% + $FeSO_4$ 0.4%	20.37±0.350b	14.74±0.079b	3.18±0.018b	17.92±0.062b
T_7	Borax 0.2% + $FeSO_4$ 0.4%	21.73±0.452a	14.90±0.109ab	3.34±0.053ab	18.24±0.155b
T_8	$ZnSO_4$ 0.4% + Borax 0.2% + $FeSO_4$ 0.4%	22.63±0.106a	15.77±0.203a	3.59±0.038a	19.36±0.240a
	S.Em±	0.31	0.29	0.08	0.35
	C. D. (P=0.05)	0.93	0.87	0.25	1.08

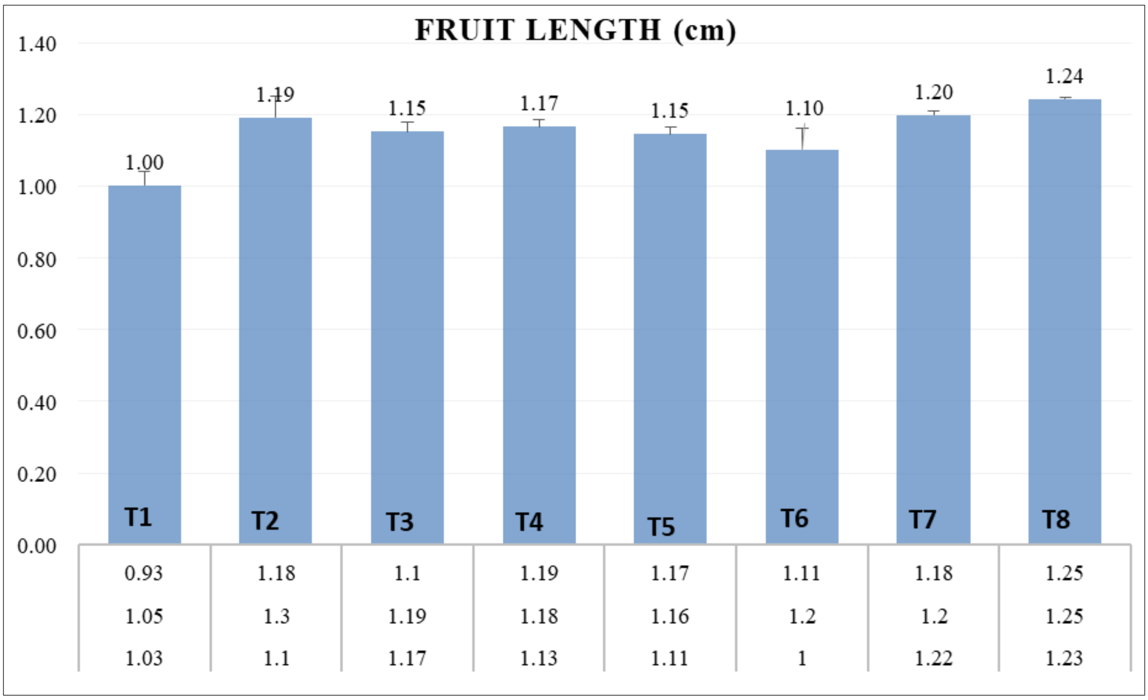

Fig 1: Effect of foliar application of micronutrients on fruit length of phalsa

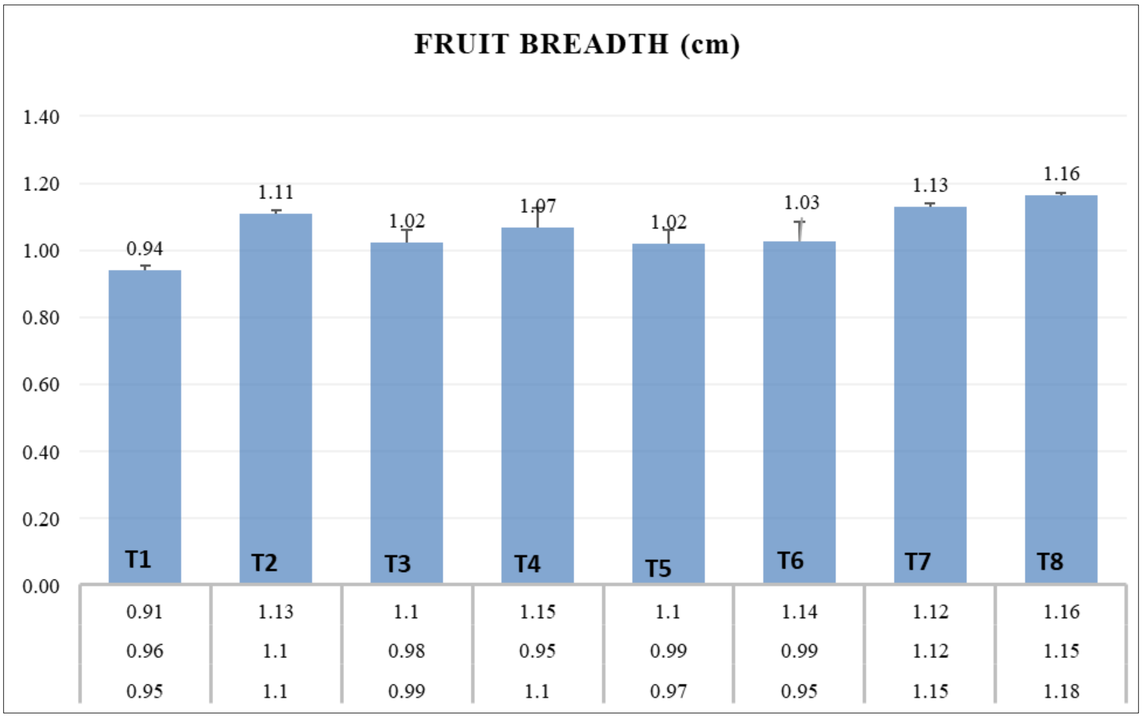

Fig 2: Effect of foliar application of micronutrients on fruit breadth of phalsa

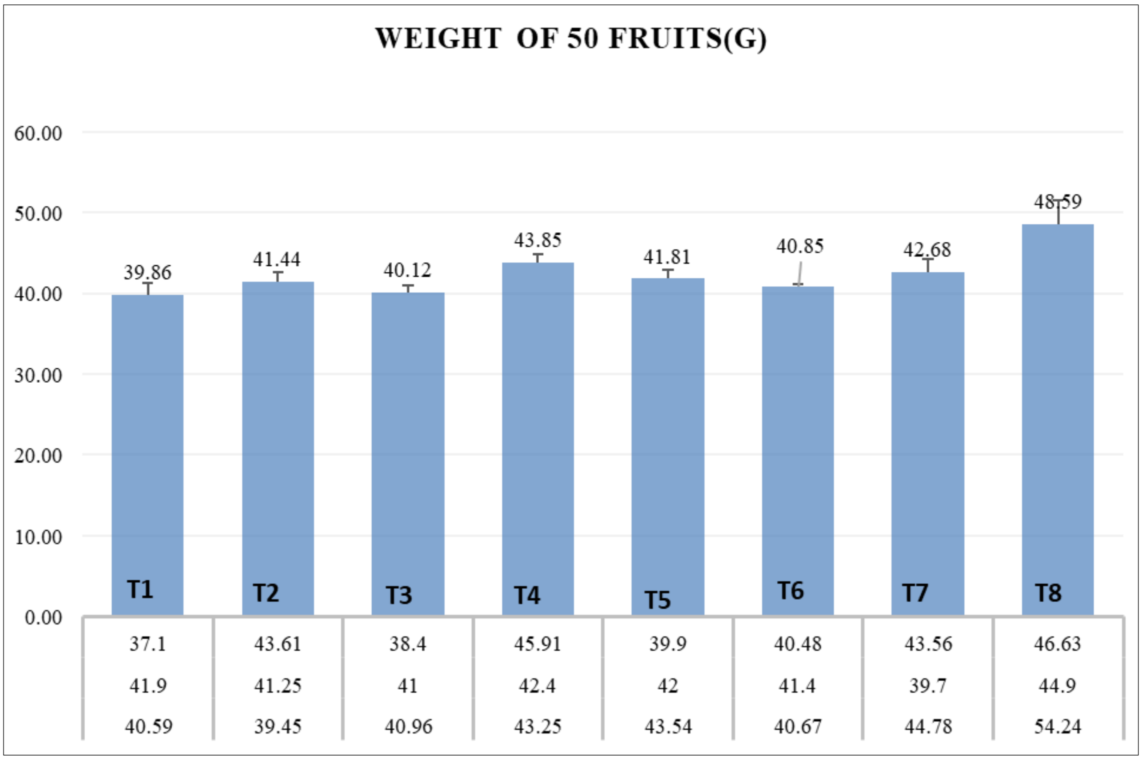

Fig 3: Effect of foliar application of micronutrients on fruit weight of phalsa

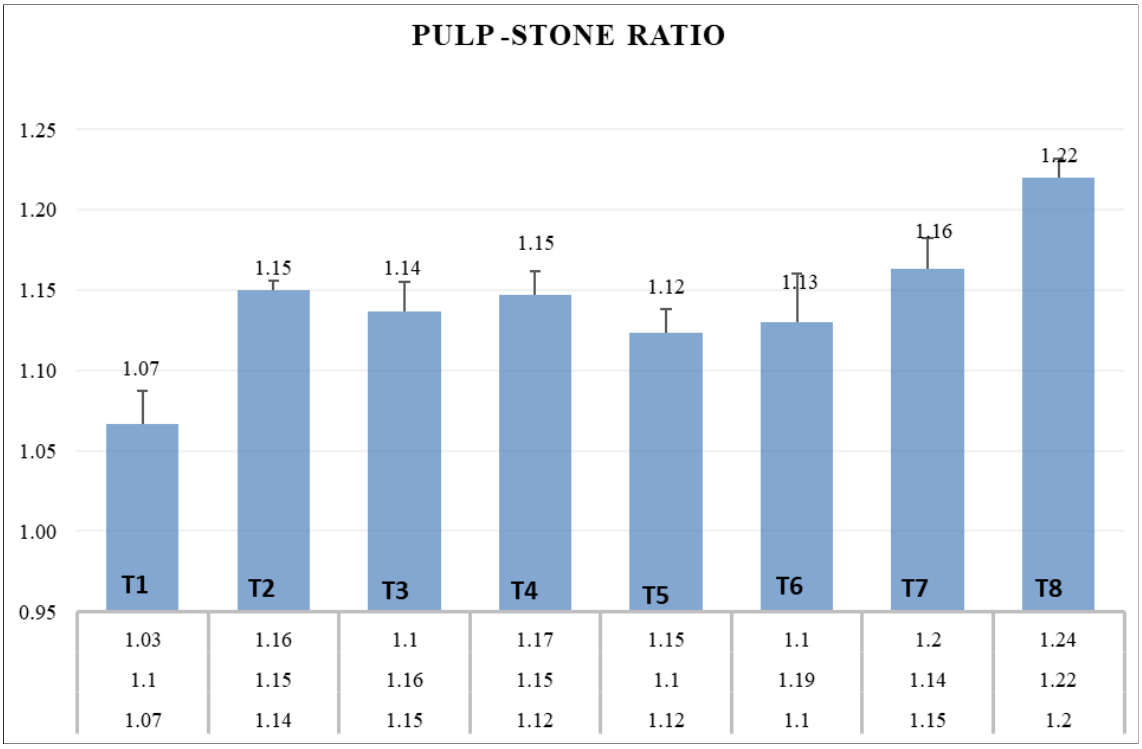

Fig 4: Effect of foliar application of micronutrients on pulp-stone ratio of phalsa

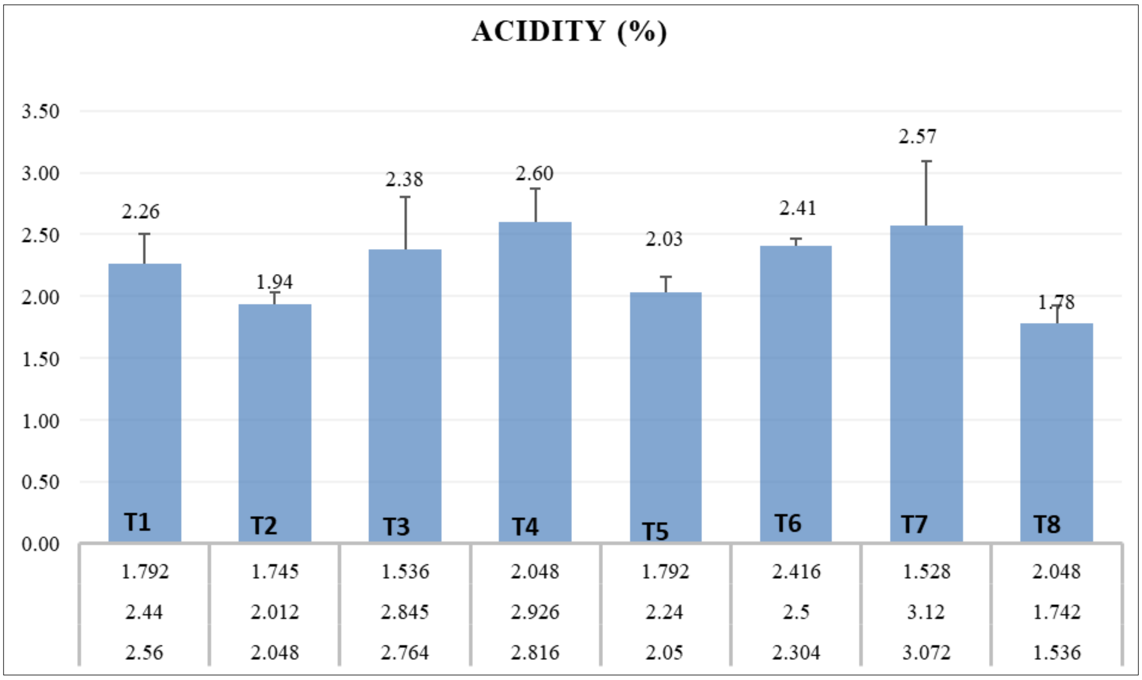

Fig 5: Effect of foliar application of micronutrients on acidity percentage of phalsa

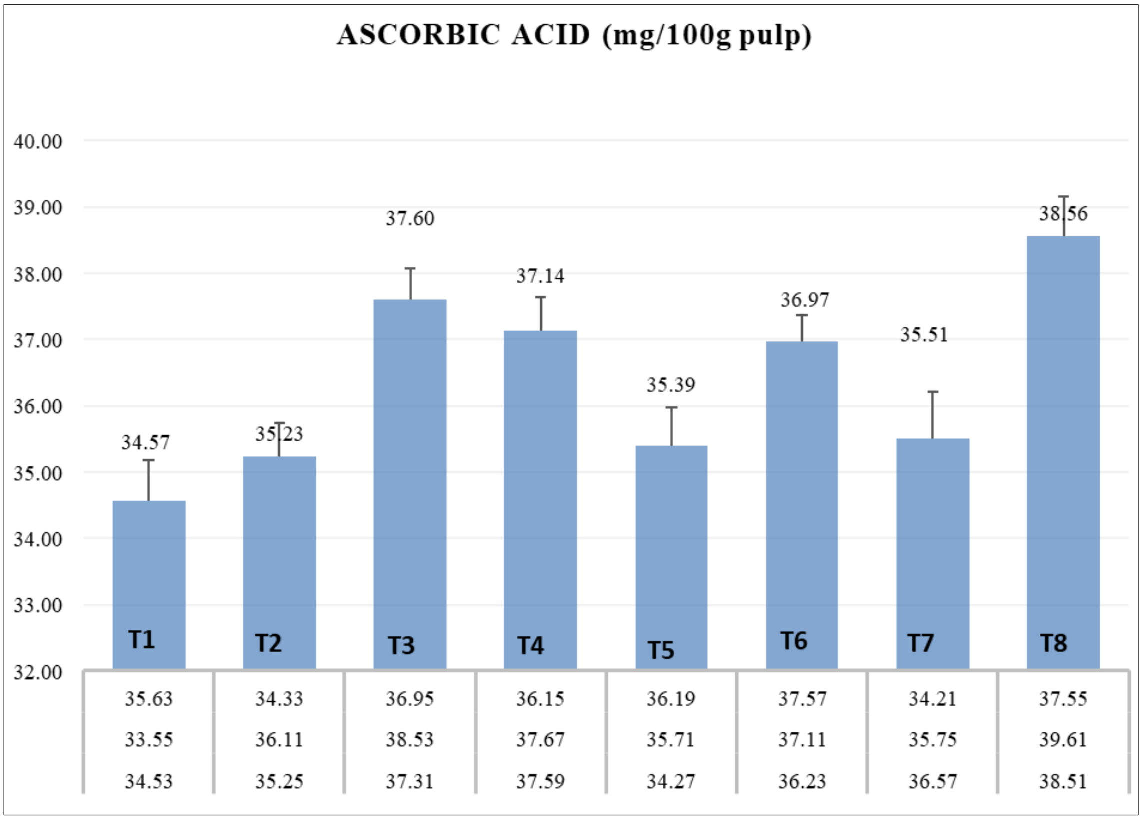

Fig 6: Effect of foliar application of micronutrients on ascorbic acid of phalsa

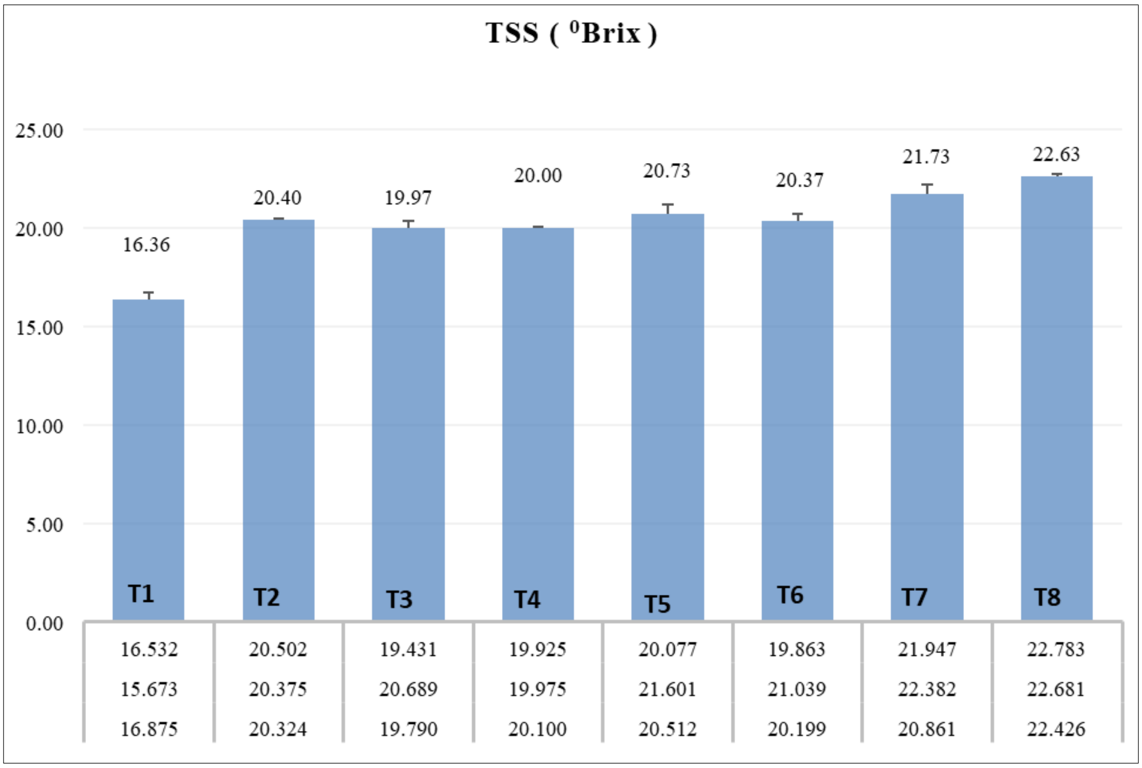

Fig 7: Effect of foliar application of micronutrients on TSS of phalsa

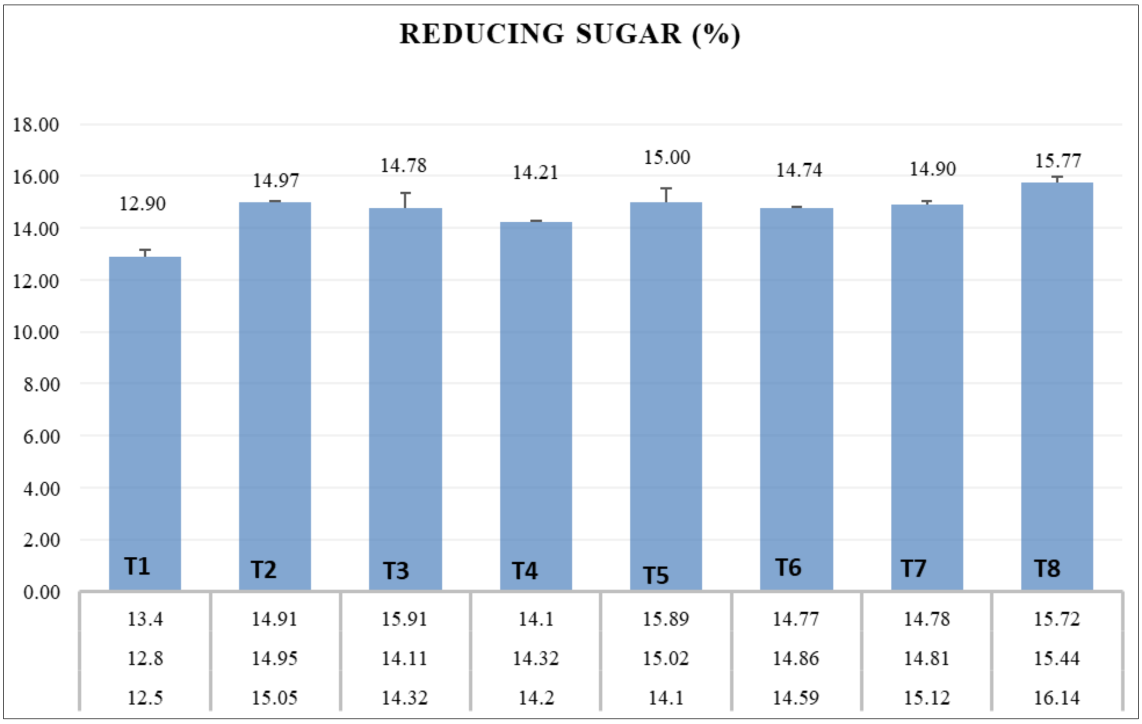

Fig 8: Effect of foliar application of micronutrients on reducing sugar of phalsa

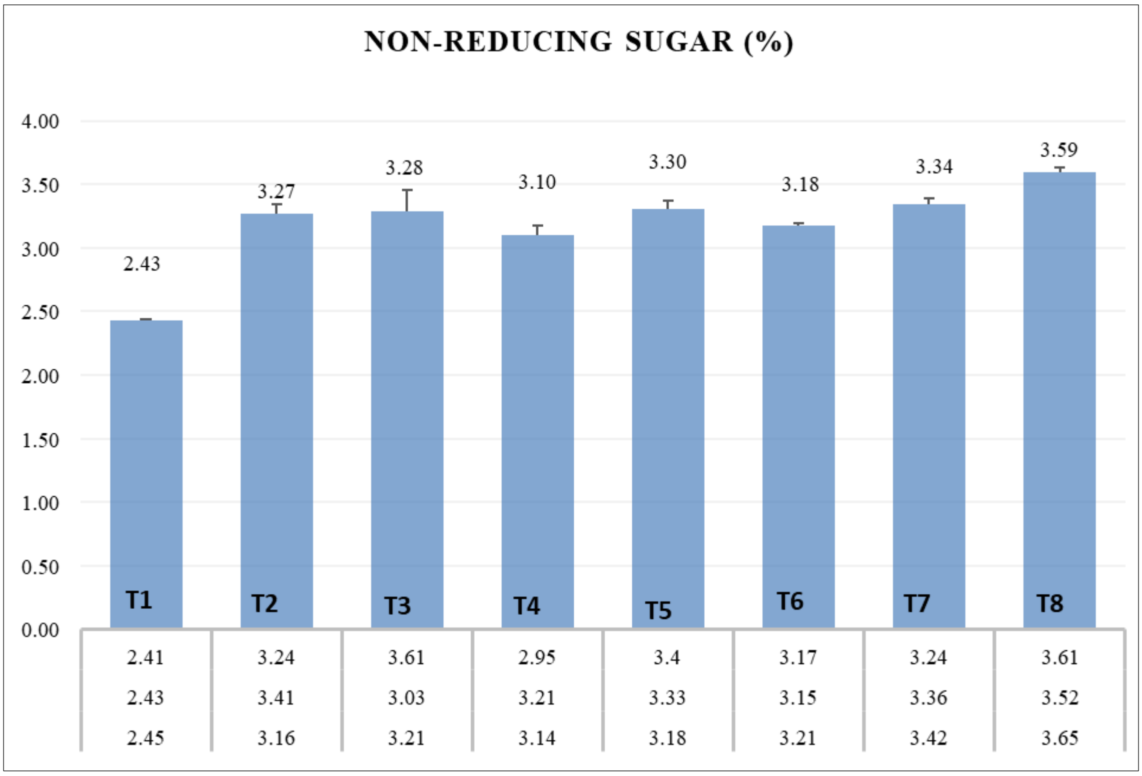

Fig 9: Effect of foliar application of micronutrients on non -reducing sugar of phalsa

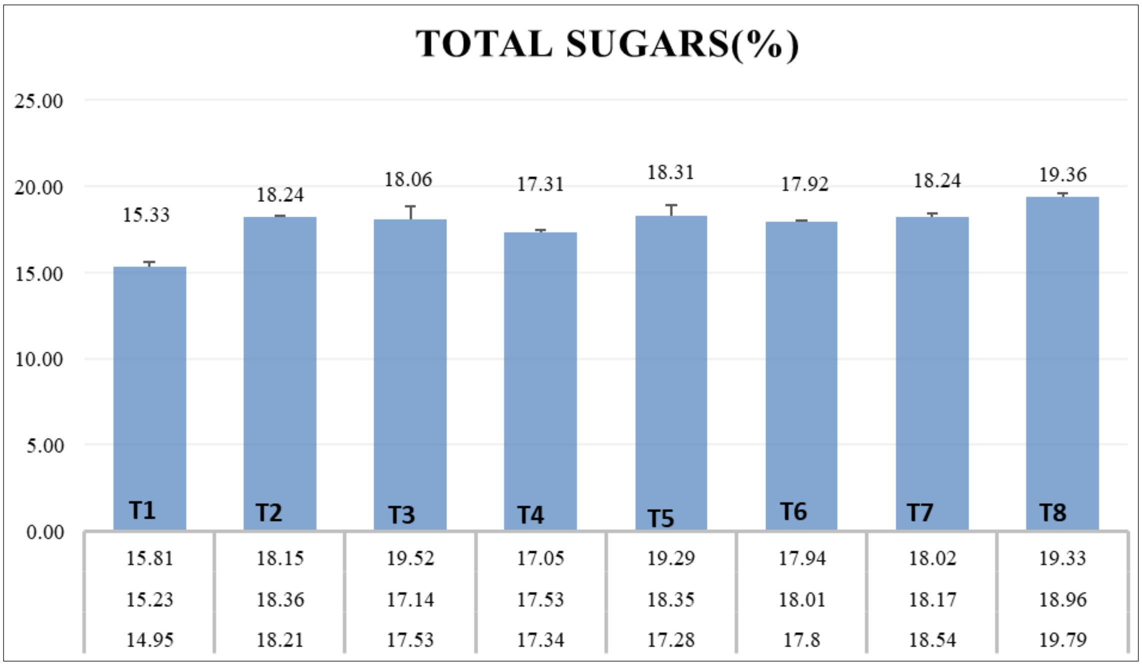

Fig 10: Effect of foliar application of micronutrients on total sugars of phalsa

Conclusion

Based on the results, it can be concluded that two times foliar application of micronutrients at pre bloom stage and just after fruit set showed significantly positive response in phalsa. The application of Zinc sulphate 0.4% + Borax 0.2% + Ferrous sulphate 0.4% significantly improve the quality in terms of physico-chemical attributes i.e., bigger size and heavy fruits with better pulp/stone ratio, least acidity, highest ascorbic acid, TSS, and sugars. Hence, The foliar application of the combination of zinc(0.4%), Borax (0.2%) and Ferrous sulphate (0.4%) is recommended to the phalsa grower to obtain best quality fruits

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