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Effect of pruning intensity and foliar nutrition on growth, yield and quality of *phalsa* cv. Sharbati

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ABSTRACT

The experiment was conducted with two factors, *viz.,* pruning intensity (A_1-30 cm and A_2-60 cm) and nutrients (B_1- control, B_2-$ZnSO_4$ 0.5%, B_3- $CuSO_4$ 0.5%, B_4- K_2SO_4 0.5% and B_5- urea 2%). The results revealed the significantly highest number of shoots per plant (33.33), length of shoot (140.45cm), girth of shoot (0.91cm), inter-nodal length (6.41 cm), number of fruiting nodes per plant (18.96), fruiting nodes per shoot (18.84), number of fruits per node (16.75), weight of 50 fruits (46.81g), fruit yield per plant (3.95 kg) and the juice content (50.91%), total soluble solids (28.04°Brix), ascorbic acid (36.28 mg/100 g pulp) and total sugars (16.80%) with lowest titratable acidity (1.82%) in treatment A_2B_2 (60 cm + $ZnSO_4$ 0.5%). Further, it was found that the treatment A_2B_2 (60 cm + $ZnSO_4$ 0.5%) proved to be the most effective treatment to improve the growth, yield and fruit quality traits of *phalsa* cv. Sharbati.

Key words: *Grewia asiatica* L., pruning intensity, $ZnSO_4$, fruit quality, juice content.

INTRODUCTION

Phalsa, a native fruit of subtropical and tropical regions, is valued for its distinctive flavour, nutritional benefits and adaptability to diverse climates. Among its cultivars, Sharbati stands out for its superior taste, sweetness and nutrient density. The small bush produces numerous deep reddish-purple berries, rich in vitamins A and C, antioxidants and minerals (Kaur, 8), making it a choicest fruit in the domestic as well as overseas markets. Despite its adaptability, *phalsa* thrives best in warm, moist conditions, but optimizing its cultivation poses significant challenges, particularly in managing vegetative growth, enhancing yield and improving fruit quality (Saroj *et al.*, 15). One of the significant challenges in phalsa cultivation is achieving an optimal balance between vegetative growth and fruit production. Excessive vegetative growth causes overcrowding, reduced light penetration and poor air circulation, all of which negatively affect fruit yield and quality. Effective management of plant growth is crucial to maintain a balance between the vegetative and reproductive growth (Meenakshi *et al.*, 14). Pruning plays an essential role in regulating this balance. Since, *phalsa* produces fruit on new season growth, annual pruning is necessary to remove old growth, and encourage the emergence of new shoots. Proper pruning not only enhances yield and fruit quality, but also helps to control plant vigour, facilitating easier harvesting, and improving the overall efficiency of fruit production.

Phalsa is a heavy feeder crop and nutrient deficiencies can limit both vegetative as well as reproductive growth. Balanced nutrition, including both macro- and micro-nutrients, can enhance yield potential. Micro-nutrients like zinc (Zn) and copper (Cu) are required for various physiological functions such as photosynthesis, respiration and enzymatic activities (Kumari *et al.*, 10). Potassium (K) plays a crucial role in protein synthesis. Nitrogen (N), as a macronutrient, influences chlorophyll production, shoot and root development and fruit quality parameters such as colour, sugar content and firmness (Sutariya *et al.*, 18). Given these challenges, employing foliar feeding to provide essential nutrients presents in a viable solution, when soil nutrient availability is insufficient. The foliar application of nutrients is advantageous for promoting plant growth and maintaining yield. Additionally, the intensity of pruning effectively manages canopy structure, enhance flowering and fruiting and improve both yield and quality across various fruit crops. Therefore, understanding the effects of pruning intensity and the foliar feeding of key nutrients, such as $ZnSO_4$, is vital for optimizing *phalsa* cultivation. This study seeks to address these significant research gaps by evaluating the combined impact of pruning intensity and foliar feeding on vegetative growth, yield and fruit quality of Sharbati phalsa.

MATERIALS AND METHODS

The field experiment was conducted over two consecutive years, from 2022 to 2024, at the

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Horticulture Garden, Department of Fruit Science, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh on uniformly sized bushes, planted at a spacing of 3.0 m × 2.5 m. The experiment was designed using a Factorial Randomized Block Design with three replications, incorporating 10 treatment combinations including two factors: pruning intensity (A_1 = 30 cm, A_2 = 60 cm) and nutrient treatments (B_1 = Control, B_2 = $ZnSO_4$ 0.5%, B_3 = $CuSO_4$ 0.5%, B_4 = K_2SO_4 0.5%, B_5 = Urea 2%). These treatments were applied in combinations *viz.,* A_1B_1 (30 cm + Control), A_1B_2 (30 cm + $ZnSO_4$ 0.5%), A_1B_3 (30 cm + $CuSO_4$ 0.5%), A_1B_4 (30 cm + K_2SO_4 0.5%), A_1B_5 (30 cm + Urea 2%), A_2B_1 (60 cm + Control), A_2B_2 (60 cm + $ZnSO_4$ 0.5%), A_2B_3 (60 cm + $CuSO_4$ 0.5%), A_2B_4 (60 cm + K_2SO_4 0.5%) and A_2B_5 (60 cm + Urea 2%). The pruning of the bushes was conducted in the first week of January at the heights of 30 and 60 cm from the ground level, in accordance with the specified treatment requirements. The first foliar application of nutrients, applied in the second fortnight of March during the flowering period, while the second foliar application was administered following fruit set. To ensure through foliar coverage, 6-liter solution was administered using a pneumatic hand sprayer with a nozzle, targeting the entire foliage between 4:00 pm and 6:00 pm. Other management practices were followed as per standard package of practices.

The observations were recorded on different traits related to growth attributes, *viz.*, number of shoots per plant, length of shoot (cm), girth of shoot (cm), inter-nodal length (cm), number of fruiting nodes per plant, fruiting nodes per shoot, number of fruits per node, weight of 50 fruits (g), fruit yield per plant were meticulously measured and recorded. Additionally, qualitative characteristics were assessed, encompassing the juice percentage, TSS, titratable acidity, ascorbic acid and total sugar. These parameters were evaluated using methodologies recommended by the AOAC (1).

Statistical analysis of the data was conducted following the standard procedures outlined by Gomez and Gomez (7). This analysis was utilized to evaluate the growth, yield and quality attributes of the plants. Treatment means were compared using Duncan's Multiple Range Test (DMRT) at a significance level of $p \leq 0.05$. DMRT was conducted to validate results using XLSTAT 2014.5.03 software.

RESULTS AND DISCUSSION

The number of shoots per plant and shoot length were significantly affected by the various combinations of nutrient treatments and pruning intensities (Table 1). The highest number of shoots (33.33) was recorded in treatment A_2B_2 (60 cm + $ZnSO_4$ 0.5%), while the lowest number of shoots per plant (24.70) was observed in treatment A1B1 (control). Significantly longest shoot (140.45 cm) was recorded in treatment A_2B_2 (60 cm + $ZnSO_4$ 0.5%), whereas it was shortest (117.73 cm) in plants kept as control (A_1B_1). These results indicate an increase in the number of shoots per plant compared to the untreated control. Zinc stimulates enzymes involved in several metabolic processes in plants, such as the production of proteins, chlorophyll and carbohydrates. Previous studies have also demonstrated this effect (Verma *et al.*, 19; Singh and Singh, 17; Chaturvedi *et al.*, 5) in phalsa. When the apical buds are removed through pruning, it invigorates the development of parallel buds, leading to the emergence of more number of new shoots and

Table 1. Effect of different pruning intensity and foliar nutrition on vegetative growth parameters of *phalsa* cv. Sharbati (pooled mean for two seasons).

Treatment	No. of shoots/ plant	Shoot length (cm)	Shoot girth (cm)	Inter-nodal length (cm)
A_1B_1 (30 cm + Control)	29.46c	127.33d	0.81e	6.06cd
A_1B_2 (30 cm + $ZnSO_4$ 0.5%)	31.02b	137.88ab	0.90ab	6.31ab
A_1B_3 (30 cm + $CuSO_4$ 0.5%)	29.51c	129.56cd	0.825de	6.12bcd
A_1B_4 (30 cm + K_2SO_4 0.5%)	29.99bc	131.48bcd	0.84cde	6.14bcd
A_1 B_5 (30 cm + Urea 2%)	29.77bc	132.37bcd	0.85cd	6.12bcd
A_2B_1 (60 cm + Control)	24.70d	117.73e	0.77f	5.94d
A_2B_2 (60 cm + $ZnSO_4$ 0.5%)	33.33a	140.45a	0.91a	6.41a
A_2B_3 (60 cm + $CuSO_4$ 0.5%)	29.56bc	131.79bcd	0.84cde	6.18bc
A_2B_4 (60 cm + K_2SO_4 0.5%)	30.53bc	135.64abc	0.87bc	6.23abc
A_2B_5 (60 cm + Urea 2%)	30.08bc	137.42ab	0.90ab	6.18bc

Different letters in the same column specify significant difference (*$P \leq 0.05$*).

branches, which is also supported by Mahendra *et al.* (12) in phalsa.

The girth of shoot was influenced by various treatment combination of nutrient and pruning intensities (Table 1). The significantly highest shoot girth (0.91 cm) was recorded in treatment A_2B_2 (60 cm + $ZnSO_4$ 0.5%), whereas the minimum girth of shoot (0.77 cm) was observed in A_1B_1 treatment. The results exhibited an increase in the girth of shoot per plant compared to untreated pant. Pruning of the terminal bud promotes the growth of parallel buds, resulting in a bushier plant with thicker shoot. Zinc is an important component in the synthesis and transportation of auxin. Auxin induces cell division and elongation, which results in an increase in shoot girth. Similar finding was reported by Verma *et al.* (19) in *phalsa*.

The results showed an increased inter-nodal length in treated plants as compared to the untreated plant (Table 1). The significantly highest length of inter-nodes (6.41 cm) was recorded with the treatment A_2B_2 (60 cm + $ZnSO_4$ 0.5%), whereas it was lowest (5.94 cm) with the treatment A_1B_1 (control). Pruning of the terminal bud empowers the development of parallel buds, resulting in a bushier plant with a thicker branch. Zinc is a component of the synthesis and transportation of auxin. Auxin induces cell division and elongation, which leads to an increase in the length of branch, which results in an increase in inter-nodal length. Similar finding were also demonstrated by Mahendra *et al.* (12) and Singh and Singh (17) in *phalsa*.

The number of fruiting nodes per plant, as well as the number of shoots and fruits per node, were significantly influenced by the tested treatment combinations (Table 2). The highest number of fruiting nodes (18.96 / plant), shoots (18.84/node) and fruits (16.75/node) were recorded in treatment A_2B_2 (60 cm + $ZnSO_4$ 0.5%), whereas these were lowest in A_1B_1 treatment (control). Pruned plants generate new, vigorous shoots that are more likely to develop flower buds, as pruning facilitates adequate light exposure, which is essential for flower bud initiation and fruiting node development. Zinc plays a crucial role by activating enzymes involved in biochemical reactions that lead to reproductive development in plants. These findings are consistent with the research of Meena *et al.* (13) in guava and Lakra *et al.* (11) on *phalsa*. The observed expansion in growth parameters might be credited to zinc's activation of various enzymes essential for photosynthesis, as well as its vital role in plant metabolism. Additionally, the application of urea, a key protein component, is critical for protoplasm formation, influencing cell division and elongation, which promotes better plant growth. Similar results were reported by Kumar *et al.* (9) on *phalsa*.

Effect of various treatment combinations of pruning level and micro-nutrients was also found significant in respect to the weight of 50 fruits and yield per plant (Table 2). The highest weight of 50 fruits (46.81 g) and yield per plant (3.95 kg) was noted in A_2B_2 (60 cm + $ZnSO_4$ 0.5%), which were lowest in A_1B_1 (control). Pruning provides more sunlight exposure which boosts the plant's photosynthetic rate, resulting in an increased production of carbohydrates. These carbohydrates are essential for fruit growth, contributing to yield. The present finding is confirmed

Table 2. Effect of different pruning intensity and foliar nutrition on fruit and yield parameters of *phalsa* cv. Sharbati (pooled mean for two seasons).

Treatment	No. of fruiting nodes/plant	No. of fruiting nodes/shoot	No. of fruits/ node	Weight of 50 fruits (g)	Fruit yield (kg)/plant)
A_1B_1 (30 cm + Control)	16.86c	16.83e	15.35d	44.41bc	2.31e
A_1B_2 (30 cm + $ZnSO_4$ 0.5%)	18.57a	18.38ab	16.42abc	46.20ab	3.73bcd
A_1B_3 (30 cm + $CuSO_4$ 0.5%)	17.195bc	17.085e	15.52cd	44.615abc	3.63cd
A_1B_4 (30 cm + K_2SO_4 0.5%)	17.32bc	17.35de	15.77bcd	45.14ab	3.58d
A_1 B_5 (30 cm + Urea 2%),	17.68b	17.53cde	15.93abcd	45.30ab	3.69bcd
A_2B_1 (60 cm + Control)	15.80d	15.75f	14.30e	42.83c	2.46e
A_2B_2 (60 cm + $ZnSO_4$ 0.5%)	18.96a	18.84a	16.75a	46.81a	3.95a
A_2B_3 (60 cm + $CuSO_4$ 0.5%)	17.53b	17.34de	15.69bcd	44.82abc	3.78abc
A_2B_4 (60 cm + K_2SO_4 0.5%)	17.78b	17.88bcd	16.19abcd	45.87ab	3.82ab
A_2B_5 (60 cm + Urea 2%)	18.50a	18.23abc	16.51ab	46.20ab	3.78abc

Different letters in the same column specify significant difference (*$P \leq 0.05$*).

by Bhagwati *et al.* (4) in guava. Zinc increased photosynthesis leading to the higher accumulation of sugars and other carbohydrates in fruits, enhancing their size, weight and quality, ultimately boosting the overall yield. The current findings are in conformity with the report of Verma *et al.* (19) on *phalsa* and Bhadauria *et al.* (3) in *aonla*.

The information given in Table 3 demonstrated an increase in juice percentage due to various combinations of nutrient treatments and pruning intensities over untreated plants. The highest juice content (50.91%) was recorded in treatment A_2B_2 (60 cm + $ZnSO_4$ 0.5%), while it was lowest (36.92%) in treatment A_1B_1 (control). Zinc acts as an essential cofactor for enzymes engaged with the synthesis of sugars and organic acids; higher sugar content leads to increased juice volume with improved quality. Additionally, zinc enhances the plant's overall water uptake and retention capabilities, which contributes to higher water content in fruits. The combination of pruning and zinc application promotes photosynthesis and nutrient use efficiency, resulting in juicier fruits. Similar findings have also been reported by Verma *et al.* (19) and Singh *et al.* (16) on *phalsa*.

Total soluble solids (TSS) was significantly influenced by various treatment combinations of nutrient and pruning intensities. The significantly highest TSS (28.04°Brix) was recorded in A_2B_2 (60 cm + $ZnSO_4$ 0.5%), whereas it was lowest (19.17^{0}Brix) in A_1B_1 (control). Pruning induces a mild stress response in plants, which sometimes leads to the accumulation of sugars as a survival mechanism. This stress can enhance the TSS content in the fruit by promoting the synthesis and storage of sugars. Zinc is a key cofactor for various enzymes involved in carbohydrate metabolism, including those which are responsible for the production and breakdown of carbohydrates. The current discoveries are in conformity with Kumar *et al.* (9) on *phalsa*; Dhakad *et al.* (6) in mulberry. Adequate zinc levels enable these enzymes work efficiently, resulting to greater sugar content in fruits and consequently increased TSS. The current in conformity with the findings of Singh *et al.* (16), Aziz *et al*. (2) on *phalsa*.

The titratable acidity of phalsa was influenced significantly by various treatment combinations of nutrient and pruning intensities (Table 3). The lowest acidity (1.82%) was recorded in A_2B_2 (60 cm + $ZnSO_4$ 0.5%). Pruning and zinc sulphate both increase the plant's capacity to synthesize and storage of sugars. Elevated sugar levels in fruits may diminish the concentration of organic acids, resulting in reduced acidity. The current finding is in conformity with the report of Kumar *et al.* (9), Chaturvedi *et al.* (5) and Aziz *et al.* (2) on *phalsa*.

The ascorbic acid content was influenced significantly by various treatment combinations of nutrient and pruning intensities (Table 3). The significantly highest value for ascorbic acid content (36.28 mg/100 g juice) was noted in A_2B_2 (60 cm + $ZnSO_4$ 0.5%). Pruning improved light penetration and photosynthesis resulting in the synthesis of carbohydrates and ascorbic acid. Zinc is crucial for the production of ascorbic acid. It serves as a cofactor for enzymes participating in the production of ascorbic acid from glucose. Optimal zinc levels facilitate the effective conversion of glucose to ascorbic acid, hence enhancing its concentration in fruits. The present finding is in conformity with the report of Dhakad *et al.* (6) in mulberry, and Chaturvedi *et al.* (5) on *phalsa*.

Table 3. Effect of different pruning intensity and foliar nutrition on quality parameters of *phalsa* cv. Sharbati (pooled mean for two seasons).

Treatment	Juice content (%)	TSS (°Brix)	Titratable acidity (%)	Ascorbic acid (mg/100 g pulp)	Total sugars (%)
A_1B_1 (30 cm + Control)	46.21d	19.17d	2.13bcd	31.18e	15.47de
A_1B_2 (30 cm + $ZnSO_4$ 0.5%)	48.03bc	27.64ab	2.11cd	34.46bc	16.44ab
A_1B_3 (30 cm + $CuSO_4$ 0.5%)	47.42bcd	26.62ab	2.21ab	31.16e	15.56cd
A_1B_4 (30 cm + K_2SO_4 0.5%)	48.55bc	26.91ab	2.06de	32.31de	15.87bcd
A_1 B_5 (30 cm + Urea 2%),	47.23cd	26.16b	2.15bcd	33.37cd	15.86bcd
A_2B_1 (60 cm + Control)	36.92e	21.15c	2.29a	27.65f	14.79e
A_2B_2 (60 cm + $ZnSO_4$ 0.5%)	50.91a	28.04a	1.82f	36.28a	16.80a
A_2B_3 (60 cm + $CuSO_4$ 0.5%)	48.64b	26.34b	2.29a	31.15e	15.65bcd
A_2B_4 (60 cm + K_2SO_4 0.5%)	50.89a	27.63ab	2.00e	33.45cd	16.28abc
A_2B_5 (60 cm + Urea 2%)	48.25bc	27.15ab	2.18bc	35.57ab	16.26abcd

Different letters in the same column specify significant difference ($P \leq 0.05$).

The content of total sugars was influenced by the various treatment combinations of nutrient and pruning intensities (Table 3). The treatment A_2B_2 (60 cm + $ZnSO_4$ 0.5%) tended to show the significantly highest total sugars (16.80%), whereas it was lowest (14.79%) in A_1B_1 (control). Zinc is vital for chlorophyll synthesis, which is necessary for photosynthesis. Enhanced photosynthesis increases the plant's capacity to synthesize carbohydrates, also helps in maintaining the stability and permeability of cell membranes. This ensures effective nutrient transport into the fruit cells, leading to enhanced sugar accumulation within the fruits. The current finding is in conformity with the report of Verma *et al.* (19), Kumar *et al.* (9) and Chaturvedi *et al.* (5) in phalsa.

Based on the findings of the current experiment, it can be concluded that pruning intensity at 60 cm over the ground level, joined with a foliar spray of $ZnSO_4$ at 0.5%, significantly enhanced the growth, yield and quality parameters of *phalsa* (*Grewia asiatica* L.). Therefore, the application of a foliar spray of $ZnSO_4$ at 0.5% alongside pruning at this height is recommended to achieve improved vegetative growth, yield and biochemical quality in *phalsa*. Future research could investigate long-term effects, nutrient synergies, responses across different cultivars and adaptations to various climates. These findings can help optimize practices for better yields and quality, benefiting phalsa growers.

AUTHORS' CONTRIBUTIONS

Conceptualization of research (RKY); Designing of the experiments (VKT); Contribution of experimental materials (RKY); Execution of field/lab experiments and data collection (RKY, VKT); Analysis of data and interpretation (RKY, VKT); Preparation of the manuscript (RKY); Review and editing (VKT).

CONFLICT OF INTEREST

The authors declare no competing interests.

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