



Plant Archives

Journal homepage: <http://www.plantarchives.org>

DOI Url : <https://doi.org/10.51470/PLANTARCHIVES.2026.v26.no.2.054>

STUDIES ON PRUNING INTENSITY AND BIOFERTILIZER APPLICATION FOR IMPROVING GROWTH, FLOWERING BEHAVIOUR AND YIELD ATTRIBUTES OF GRAPES (*Vitis vinifera* L.) CV. ARKA KANCHAN

Sonia Bist*, Shilpa Rana, Vijay Bahadur, Samir Ebson Topno and Yashasvi Shukla

Department of Horticulture, Naini Agricultural Institutes, SHUATS, Prayagraj-211007, U.P., India.

*Corresponding author E-mail: soniabist78@gmail.com

(Date of Receiving-06-06-2026; Date of Revision-30-07-2026; Date of Acceptance-20-08-2026)

ABSTRACT

Present investigation was conducted during 2025–26 at the Horticultural Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj, Uttar Pradesh. The experiment was laid out in a Factorial Randomized Block Design (FRBD) with three pruning intensities [P_0 : no pruning, P_1 : 2-bud spur at 8 positions (75%) heavy pruning and P_2 : 4-bud spur at 8 positions (50%) moderate pruning] and three biofertilizer treatments [B_0 : control, B_1 : RDF (100%) + Azotobacter + PSB + VAM and B_2 : RDF (75%) + Azotobacter + PSB + VAM + Azospirillum], and their interaction. The study evaluated the combined effects of pruning intensity and biofertilizer application on vegetative growth, flowering behaviour, yield attributes, and economics of grape. Among the interactions, P_2B_2 [moderate pruning + RDF (75%) + Azotobacter + PSB + VAM + Azospirillum] significantly enhanced vegetative growth, flowering and yield, recording the earliest bud burst (51.33 days) and flowering (72.33 days), highest bud burst (31.08%), chlorophyll content (35.50 SPAD), vine spread (2.90 m²), fruit set (89.68%), clusters per vine (28.33), berries per cluster (118.07). However, P_2B_1 [moderate pruning + RDF (100%) + Azotobacter + PSB + VAM] produced the highest average cluster weight (275.08 g), yield per vine (7.06 kg), yield per hectare (17.65 t ha⁻¹), gross return (Rs. 17,64,667 ha⁻¹), net return (Rs. 14,50,502 ha⁻¹) and benefit:cost ratio (5.62). Thus, moderate pruning integrated with biofertilizer application proved to be an effective and sustainable strategy for improving productivity, fruit quality and profitability of Arka Kanchan grape under Prayagraj agro-climatic condition.

Key words: Grape, *Vitis vinifera*, pruning intensity, biofertilizers, Azotobacter, PSB, VAM, Azospirillum, yield.

Introduction

Grape (*Vitis vinifera* L.) is one of the most important fruit crops cultivated worldwide for fresh consumption, raisin production, juice, and wine industries. China is the leading grape-producing country, followed by Italy, the United States, Spain, France, Türkiye, and India. Globally, grapes are cultivated over approximately 7.46 million hectares with an annual production of about 77.8 million tonnes (Atak, 2024). In India, grape cultivation occupies about 1.40 lakh hectares with an annual production of nearly 30.41 lakh tonnes, making it an economically important horticultural crop (Khadatkar *et al.*, 2018). Among various vineyard management practices, pruning

is the most important cultural operation because grapevines bear fruits on the current season's shoots arising from one-year-old canes. Pruning regulates bud load, shoot emergence, canopy architecture, flowering, berry development, yield, and fruit quality while maintaining a balanced source–sink relationship and improving light penetration and air circulation within the canopy (Morris *et al.*, 2009). Appropriate pruning is therefore essential for achieving optimum productivity and superior fruit quality. Sustainable nutrient management is another key factor influencing grape production. Excessive dependence on chemical fertilizers has resulted in declining soil fertility, nutrient imbalance, reduced

fertilizer-use efficiency, and environmental pollution through nutrient losses (Chhonkar, 2008; Singh *et al.*, 2014). Consequently, biofertilizers have gained importance as eco-friendly alternatives that improve nutrient availability, soil health, and crop productivity by enhancing beneficial microbial activity (ICAR, 2011; Mani *et al.*, 2013). Microorganisms such as *Azotobacter*, *Azospirillum*, phosphate-solubilizing bacteria (PSB), and vesicular-arbuscular mycorrhiza (VAM) enhance nutrient uptake, fix atmospheric nitrogen, solubilize phosphorus, stimulate root growth, and produce plant growth-promoting substances, thereby improving vegetative growth, yield, and fruit quality (Soorianathasundaram *et al.*, 2000; Mani *et al.*, 2013). Several studies have demonstrated the beneficial effects of integrated nutrient management using biofertilizers in fruit crops, including guava, aonla, phalsa, custard apple, and bael, where significant improvements in growth, nutrient uptake, yield, and fruit quality have been reported (Dutta *et al.*, 2009; Singh *et al.*, 2011; Goswami *et al.*, 2012; Mandal *et al.*, 2013; Sharma and Bhatnagar, 2014; Sharma *et al.*, 2014; Singh *et al.*, 2014). However, information regarding the combined influence of pruning intensity and biofertilizer application on Arka Kanchan grape under the agro-climatic conditions of Prayagraj is limited.

Materials and Methods

The experiment was carried out at the Horticultural Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj, Uttar Pradesh, during the winter season of 2025–26. The experimental vineyard consisted of four-year-old healthy and uniformly growing vines of grape cv. Arka Kanchan. The experiment was laid out in a Factorial Randomized Block Design (FRBD) comprising nine treatment combinations (three levels of pruning and three levels of biofertilizers) with three replications. The treatments consisted of three pruning intensities combined with different biofertilizer applications (Table 1). The pruning treatments were practiced in the month of January, 2026 and RDF were applied a day after the pruning performed in the vineyard. Biofertilizers were thoroughly mixed with FYM and incubated for 15 days to activate the microbial population, enhance soil penetration depth, and protect the living organisms from direct sunlight prior to application. biofertilizers were applied to the soil two feet away from the tree trunk after 2 weeks of pruning. Standard cultural practices, including irrigation, nutrient application, plant protection measures, and intercultural operations, were followed uniformly for all treatments throughout the experimental period. Observations on

Table 1: Factors and Interaction Details.

Factors	Factor details
Factor I (Pruning intensities)	
P ₀	Control (no pruning)
P ₁	2 bud spur 8 position (75%) Heavy
P ₂	4 bud spur 8 positions (50%) Moderate
Factor II (Biofertilizer)	
B ₀	Control (No Biofertilizer)
B ₁	RDF (100%) + <i>Azotobacter</i> (250g vine ⁻¹) + PSB (250g vine ⁻¹) + VAM (50g vine ⁻¹)
B ₂	RDF (75%) + <i>Azotobacter</i> (250g vine ⁻¹) + PSB (250g vine ⁻¹) + VAM (50g vine ⁻¹) + <i>Azospirillum</i> (250g vine ⁻¹)
Treatment Notation	Interaction
P ₀ B ₀	Control (no pruning) + Control (No Biofertilizer)
P ₀ B ₁	Control (no pruning) + RDF (100%) + <i>Azotobacter</i> (250g vine ⁻¹) + PSB (250g vine ⁻¹) + VAM (50g vine ⁻¹)
P ₀ B ₂	Control (no pruning) + RDF (75%) + <i>Azotobacter</i> (250g vine ⁻¹) + PSB (250g vine ⁻¹) + VAM (50g vine ⁻¹) + <i>Azospirillum</i> (250g vine ⁻¹)
P ₁ B ₀	2 bud spur 8 position (75%) Heavy + Control (No Biofertilizer)
P ₁ B ₁	2 bud spur 8 position (75%) Heavy + RDF (100%) + <i>Azotobacter</i> (250g vine ⁻¹) + PSB (250g vine ⁻¹) + VAM (50g vine ⁻¹)
P ₁ B ₂	2 bud spur 8 position (75%) Heavy + RDF (75%) + <i>Azotobacter</i> (250g vine ⁻¹) + PSB (250g vine ⁻¹) + VAM (50g vine ⁻¹) + <i>Azospirillum</i> (250g vine ⁻¹)
P ₂ B ₀	4 bud spur 8 positions (50%) Moderate + Control (No Biofertilizer)
P ₂ B ₁	4 bud spur 8 positions (50%) Moderate + RDF (100%) + <i>Azotobacter</i> (250g vine ⁻¹) + PSB (250g vine ⁻¹) + VAM (50g vine ⁻¹)
P ₂ B ₂	4 bud spur 8 positions (50%) Moderate + RDF (75%) + <i>Azotobacter</i> (250g vine ⁻¹) + PSB (250g vine ⁻¹) + VAM (50g vine ⁻¹) + <i>Azospirillum</i> (250g vine ⁻¹)

vegetative growth, flowering, yield and yield-attributing parameters were recorded at appropriate stages of crop growth using standard procedures. The vegetative parameters included days to bud burst, bud burst percentage, chlorophyll content (SPAD value), vine spread (North–South and East–West directions) (m²) at 60, 90 and 120 days after pruning (DAP). Flowering observations comprised days required for flowering (days), the number of inflorescences per shoot and fruit set percentage. The date of emergence of bud and initiation of flowering was recorded and expressed in number of days taken for bud burst and flowering. Yield

Table 2: Effect of different pruning intensities and biofertilizer application on growth and flowering parameters in Grape cv. Arka Kanchan.

Treatment Notation	Days to bud burst	Bud burst (%)	Chlorophyll content (SPAD value)	Vine spread (m ²) {N-S & E-W}			DF	NIPS	FS
	(* Days after pruning)			60 DAP	90 DAP	120 DAP			
P ₀	56.00	22.97	31.30	0.75	1.40	1.72	79.44	3.44	71.48
P ₁	53.56	27.43	32.73	0.93	1.84	2.21	76.67	4.33	70.19
P ₂	53.44	28.18	33.20	0.98	2.05	2.46	75.78	5.22	86.01
CD _{0.05}	4.82	3.32	0.89	0.61	0.75	0.67	4.83	0.66	1.71
SE m (±)	1.55	1.07	0.29	0.20	0.24	0.21	1.55	0.21	0.55
B ₀	57.44	22.85	30.40	0.64	1.27	1.62	80.89	3.00	68.52
B ₁	53.00	28.13	32.83	0.97	1.98	2.26	76.11	4.56	78.89
B ₂	52.56	27.60	34.00	1.05	2.04	2.50	74.89	5.44	80.26
CD _{0.05}	4.82	3.32	0.89	0.61	0.75	0.67	4.83	0.66	1.71
SE m (±)	1.55	1.07	0.29	0.20	0.24	0.21	1.55	0.21	0.55
P ₀ B ₀	59.67	11.27	29.50	0.46	0.92	1.22	84.00	2.33	55.56
P ₀ B ₁	54.33	28.82	31.40	0.84	1.59	1.95	77.33	3.67	82.22
P ₀ B ₂	54.00	28.82	33.00	0.97	1.68	1.98	77.00	4.33	76.67
P ₁ B ₀	55.67	28.82	31.20	0.73	1.51	1.85	78.67	3.33	69.44
P ₁ B ₁	52.67	30.56	33.50	0.99	2.01	2.15	76.00	4.33	66.67
P ₁ B ₂	52.33	22.92	33.50	1.06	2.00	2.62	75.33	5.33	74.44
P ₂ B ₀	57.00	28.47	30.50	0.73	1.37	1.78	80.00	3.33	80.56
P ₂ B ₁	52.00	25.00	33.60	1.07	2.33	2.69	75.00	5.67	87.78
P ₂ B ₂	51.33	31.08	35.50	1.13	2.46	2.90	72.33	6.67	89.68
CD _{0.05}	8.36	5.75	1.54	1.06	1.30	1.15	8.37	1.14	2.15
SE m (±)	2.69	1.85	0.49	0.34	0.42	0.37	2.69	0.37	0.69
CV	8.56	12.22	2.64	66.33	40.95	30.14	6.03	14.65	29.71
DF: Days to flowering; NIPS: Number of inflorescences per shoot; FS: Fruit set (%)									

and yield-attributing parameters included the average number of clusters per vine, average number of berries per cluster, average cluster weight (g), yield per vine (kg) and yield per hectare (t ha⁻¹). All observations were recorded from the selected experimental vines in each treatment and subjected to statistical analysis following the procedure appropriate for a Factorial Randomized Block Design (FRBD) by Gomez and Gomez (1984), and treatment means were compared at the 5% level of significance.

Results and Discussion

Vegetative growth and flowering parameters

The data presented in Table 2 revealed that growth and flowering parameters, namely days to bud burst, bud burst percentage, chlorophyll content, vine spread, days to flowering, number of inflorescences per shoot and fruit set, were significantly influenced by different pruning intensities, biofertilizer applications and their interaction.

Among the pruning intensities, moderate pruning (P₂: 4 bud spur at 8 positions, 50%) recorded the earliest bud burst (53.44 days), which remained statistically at par with heavy pruning (P₁: 2 bud spur at 8 positions, 75%)

(53.56 days), whereas the maximum number of days required for bud burst (56.00 days) was observed in the control (P₀). The highest bud burst percentage (28.18%) was also recorded under moderate pruning, followed by heavy pruning (27.43%), while the lowest value (22.97%) was observed in unpruned vines. Chlorophyll content was significantly enhanced under moderate pruning, recording the highest SPAD value (33.20), followed by heavy pruning (32.73), whereas the lowest chlorophyll content (31.30 SPAD) was recorded under the control. Similarly, moderate pruning produced the maximum vine spread of 0.98, 2.05 and 2.46 m² at 60, 90 and 120 DAP, respectively, followed by heavy pruning, while the minimum vine spread (0.75, 1.40 and 1.72 m², respectively) was recorded under the control. Moderate pruning also recorded the earliest flowering (75.78 days), followed by heavy pruning (76.67 days), whereas the maximum number of days to flowering (79.44 days) was recorded under the control. The highest number of inflorescences per shoot (5.22) and fruit set (86.01%) were also recorded under moderate pruning, whereas the lowest values (3.44 and 71.48%, respectively) were observed in unpruned vines.

Among the biofertilizer treatments, the application of RDF (75%) + Azotobacter + PSB + VAM + Azospirillum (B_2) significantly reduced the days to bud burst (52.56 days), which remained statistically at par with B_1 (53.00 days), while the maximum duration (57.44 days) was recorded under the control (B_0). The highest chlorophyll content (34.00 SPAD), maximum vine spread (1.05, 2.04 and 2.50 m² at 60, 90 and 120 DAP, respectively), earliest flowering (74.89 days), highest number of inflorescences per shoot (5.44) and maximum fruit set (80.26%) were recorded under B_2 . However, the highest bud burst percentage (28.13%) was recorded under B_1 , which remained statistically at par with B_2 (27.60%), whereas the lowest bud burst percentage (22.85%), chlorophyll content (30.40 SPAD), vine spread (0.64, 1.27 and 1.62 m²), number of inflorescences per shoot (3.00), fruit set (68.52%) and the latest flowering (80.89 days) were observed in the untreated control (B_0).

The interaction between pruning intensity and biofertilizer application also exerted a significant influence on all growth and flowering parameters. The combination of moderate pruning (P_2) with RDF (75%) + Azotobacter + PSB + VAM + Azospirillum (B_2) recorded the earliest bud burst (51.33 days), highest bud burst percentage (31.08%), maximum chlorophyll content (35.50 SPAD), greatest vine spread (1.13, 2.46 and 2.90 m² at 60, 90 and 120 DAP, respectively), earliest flowering (72.33 days), highest number of inflorescences per shoot (6.67) and maximum fruit set (89.68%). In contrast, the combination of control without pruning and without biofertilizer (P_0B_0) recorded the poorest performance, with the latest bud burst (59.67 days), minimum bud burst (11.27%), lowest chlorophyll content (29.50 SPAD), smallest vine spread (0.46, 0.92 and 1.22 m²), latest flowering (84.00 days), minimum number of inflorescences per shoot (2.33) and lowest fruit set (55.56%).

The improvement in growth and flowering observed under moderate pruning may be attributed to the maintenance of an optimum balance between vegetative and reproductive growth. Removal of excess and unproductive shoots reduced competition for stored carbohydrates and nutrients, promoted efficient translocation of assimilates towards actively growing buds and developing inflorescences, and improved light penetration and air circulation within the canopy. These favourable conditions enhanced photosynthetic efficiency, chlorophyll synthesis, canopy expansion, early bud burst and floral initiation, ultimately resulting in greater vine spread, higher bud sprouting, increased fruit set and improved reproductive performance. The beneficial

influence of biofertilizer application, particularly 75% RDF combined with Azotobacter, PSB, VAM and Azospirillum, may be attributed to enhanced nutrient availability through biological nitrogen fixation, phosphate solubilization, improved root growth and increased uptake of macro- and micronutrients. VAM enhanced phosphorus absorption and water uptake, whereas Azotobacter and Azospirillum stimulated root proliferation and the synthesis of plant growth-promoting substances such as auxins, gibberellins and cytokinins. These physiological processes collectively promoted chlorophyll accumulation, vigorous canopy development, earlier flowering and higher fruit set. The superior performance of the interaction treatment (P_2B_2) demonstrates the synergistic effect of optimum pruning intensity and integrated biofertilizer application in maximizing vegetative vigour and reproductive efficiency of grape under Prayagraj agro-climatic conditions. The present findings are in close agreement with the reports of Chougule (2004), who observed improved vegetative growth under optimum pruning; Chalak (2008) and Kohale *et al.*, (2013), who reported enhanced bud sprouting, flowering and vegetative development with suitable pruning intensity; Dhaliwal (2013), who observed superior shoot growth in pruned vines; Khan and Hameedunnisa (2007) and Ram and Pathak (2007), who reported improved chlorophyll content and vegetative growth through integrated nutrient management; Godage *et al.*, (2013), who observed enhanced flowering and vegetative growth with Azotobacter and phosphate-solubilizing bacteria; Sharaf *et al.*, (2011), who reported improved vine vigour with combined biofertilizer application; and Al-Doori and Hussein (2025), who demonstrated that the combined effect of appropriate pruning intensity and mycorrhizal biofertilization significantly enhanced vegetative growth, flowering and overall vine performance in grape.

Yield parameters

The data presented in Table 3 revealed that cluster, berry and yield parameters, namely average number of clusters per vine average number of berries per cluster, average cluster weight, yield per vine and yield per hectare, were significantly influenced by different pruning intensities, biofertilizer applications and their interaction.

Among the pruning intensities, moderate pruning (P_2 : 4 bud spur at 8 positions, 50%) recorded the highest average number of clusters per vine (25.11), followed by heavy pruning (P_1 : 2 bud spur at 8 positions, 75%) (24.11), whereas the lowest average number of clusters per vine (19.22) was recorded under the control (P_0). Similarly, the maximum average number of berries per cluster

Table 3: Effect of different pruning intensities and biofertilizer application on cluster, berry and yield parameters in Grape cv. Arka Kanchan.

TN	ANCV	ANBC	ACW	YV	YH
P ₀	19.22	67.99	138.83	2.81	7.02
P ₁	24.11	85.49	226.29	5.42	13.55
P ₂	25.11	96.17	247.14	6.24	15.61
CD _{0.05}	1.85	9.04	19.80	1.23	2.85
SE m (±)	0.59	2.91	6.37	0.40	0.92
B ₀	19.89	65.55	163.59	3.48	8.70
B ₁	23.67	88.76	219.34	5.24	13.10
B ₂	24.89	95.34	229.33	5.75	14.38
CD _{0.05}	1.85	9.04	19.80	1.23	2.85
SE m (±)	0.59	2.91	6.37	0.40	0.92
P ₀ B ₀	13.67	58.63	81.94	1.09	2.73
P ₀ B ₁	22.00	69.88	149.26	3.25	8.13
P ₀ B ₂	22.00	75.45	185.28	4.07	10.18
P ₁ B ₀	24.67	72.93	188.47	4.64	11.60
P ₁ B ₁	23.33	91.06	233.66	5.40	13.51
P ₁ B ₂	24.33	92.49	256.74	6.22	15.54
P ₂ B ₀	21.33	65.10	220.36	4.71	11.77
P ₂ B ₁	25.67	105.35	275.08	7.06	17.65
P ₂ B ₂	28.33	118.07	245.98	6.96	17.41
CD _{0.05}	3.20	15.65	34.29	2.13	4.93
SE m (±)	1.03	0.15	11.03	0.68	1.59
CV	7.81	10.48	9.36	24.57	9.87
TN: Treatment Notation; ANCV: Average Number of clusters per vine; ANBC: Average Number of berries per cluster; ACW: Average cluster weight (g); YV: Yield per vine (kg); YH: Yield per hectare (t/ha)					

(96.17), highest average cluster weight (247.14 g), maximum yield per vine (6.24 kg) and highest yield per hectare (15.61 t ha⁻¹) were also recorded under moderate pruning, followed by heavy pruning (85.49 berries per cluster, 226.29 g, 5.42 kg vine⁻¹ and 13.55 t ha⁻¹, respectively), while the lowest values (67.99 berries per cluster, 138.83 g, 2.81 kg vine⁻¹ and 7.02 t ha⁻¹, respectively) were observed under the control.

Among the biofertilizer treatments, the application of RDF (75%) + Azotobacter + PSB + VAM + Azospirillum (B₂) recorded the highest average number of clusters per vine (24.89), followed by RDF (100%) + Azotobacter + PSB + VAM (B₁) (23.67), whereas the lowest value (19.89) was recorded under the untreated control (B₀). Likewise, the highest average number of berries per cluster (95.34), maximum average cluster weight (229.33 g), highest yield per vine (5.75 kg) and highest yield per hectare (14.38 t ha⁻¹) were also recorded under B₂, followed by B₁ (88.76 berries per cluster, 219.34 g, 5.24 kg vine⁻¹ and 13.10 t ha⁻¹, respectively), while the lowest values (65.55 berries per

cluster, 163.59 g, 3.48 kg vine⁻¹ and 8.70 t ha⁻¹, respectively) were recorded under the untreated control (B₀).

The interaction between pruning intensity and biofertilizer application also exerted a significant influence on all cluster, berry and yield parameters. The combination of moderate pruning (P₂) with RDF (75%) + Azotobacter + PSB + VAM + Azospirillum (B₂) recorded the highest average number of clusters per vine (28.33) and the maximum average number of berries per cluster (118.07). However, the highest average cluster weight (275.08 g), yield per vine (7.06 kg) and yield per hectare (17.65 t ha⁻¹) were recorded under the combination of moderate pruning (P₂) with RDF (100%) + Azotobacter + PSB + VAM (B₁), which remained statistically at par with P₂B₂ for yield per vine (6.96 kg) and yield per hectare (17.41 t ha⁻¹). The second highest average cluster weight (256.74 g) was recorded under P₁B₂ [2 bud spur at 8 positions (75%) heavy pruning + RDF (75%) + Azotobacter + PSB + VAM + Azospirillum]. In contrast, the combination of control without pruning and without biofertilizer (P₀B₀) recorded the lowest average number of clusters per vine (13.67), minimum average number of berries per cluster (58.63), lowest average cluster weight (81.94 g), minimum yield per vine (1.09 kg) and the lowest yield per hectare (2.73 t ha⁻¹).

The significant improvement in cluster, berry and yield parameters under moderate pruning may be attributed to the maintenance of an optimum crop load and a favourable balance between vegetative and reproductive growth. Moderate pruning retained an adequate number of fruitful buds while preventing excessive competition among developing shoots and clusters for assimilates. Improved canopy architecture enhanced light interception, photosynthetic efficiency and carbohydrate translocation towards developing berries, resulting in increased cluster number, greater berry set, higher cluster weight and improved yield. In contrast, unpruned vines produced dense canopies that reduced light penetration and photosynthetic efficiency, leading to poor reproductive performance. The beneficial influence of integrated biofertilizer application, particularly 75% RDF combined with Azotobacter, PSB, VAM and Azospirillum, may be attributed to enhanced nutrient availability through biological nitrogen fixation, phosphorus solubilization and improved uptake of water and mineral nutrients by mycorrhizal associations. These microorganisms also synthesize plant growth-promoting substances that stimulate root development, improve nutrient-use efficiency and enhance photosynthetic activity, thereby increasing assimilate production and translocation to

developing clusters. Consequently, cluster development, berry formation and overall productivity were significantly improved. The superior performance of the interaction treatments demonstrates the synergistic effect of optimum pruning intensity and integrated biofertilizer application in maximizing grape yield under Prayagraj agro-climatic conditions. The highest cluster weight and yield obtained under P_2B_1 indicate that moderate pruning integrated with the full recommended dose of fertilizers along with Azotobacter, PSB and VAM ensured optimum nutrient availability for cluster development and yield formation, whereas the higher cluster number and berry number observed under P_2B_2 suggest that partial substitution of inorganic fertilizers with Azospirillum further enhanced reproductive efficiency without compromising productivity. The present findings are in close conformity with those of Somkuwar and Ramteke (2008), Chalak (2008) and Kohale *et al.*, (2013), who reported that optimum pruning intensity improved bunch production, berry number and grape yield. Similar improvements in fruit yield due to appropriate pruning were also reported by Shaban and Haseeb (2009) and Shahein *et al.*, (2010). The beneficial influence of integrated biofertilizer application on cluster development and productivity corroborates the findings of Godage *et al.*, (2013), Tangolar *et al.*, (2019) and Vijayalakshmi *et al.*, (2022), who observed significant improvements in bunch characteristics and grape productivity following integrated microbial fertilization. The results are further supported by Al-Doori and Hussein (2025), who reported that the combined application of suitable pruning intensity and mycorrhizal biofertilization significantly enhanced yield components and overall productivity in grape.

Economics parameters

The economic analysis revealed that different pruning intensities and biofertilizer applications markedly influenced the profitability of grape cultivation. Among the treatment combinations, P_2B_1 (4 bud spur at 8 positions (50%) moderate pruning + RDF (100%) + Azotobacter (250 g vine⁻¹) + PSB (250 g vine⁻¹) + VAM (50 g vine⁻¹)) proved to be the most profitable treatment, recording the highest gross return (Rs. 17,64,667 ha⁻¹), net return (Rs. 14,50,502 ha⁻¹) and benefit:cost ratio (5.62). This was closely followed by P_2B_2 (4 bud spur at 8 positions (50%) moderate pruning + RDF (75%) + Azotobacter (250 g vine⁻¹) + PSB (250 g vine⁻¹) + VAM (50 g vine⁻¹) + Azospirillum (250 g vine⁻¹)) with a gross return of Rs. 17,41,000 ha⁻¹, net return of Rs. 14,23,483 ha⁻¹ and a benefit:cost ratio of 5.48. In contrast, the control treatment (P_0B_0) (Control (no pruning) + Control (No Biofertilizer)) recorded the lowest gross return (Rs.

2,73,236 ha⁻¹), net return (Rs. 37,322 ha⁻¹) and benefit:cost ratio (1.16). The higher economic returns obtained under moderate pruning integrated with biofertilizer application were primarily associated with increased yield, improved fruit quality and efficient utilization of inputs, resulting in greater profitability of grape cultivation under Prayagraj agro-climatic conditions.

Conclusions

The present investigation demonstrated that pruning intensity and biofertilizer application significantly influenced the growth, flowering, yield and productivity of grape cv. Arka Kanchan. Among the pruning treatments, moderate pruning (4 bud spur at 8 positions; 50%) proved superior by promoting better vegetative growth, earlier flowering, higher fruit set and improved yield attributes. Integrated application of RDF (75%) along with Azotobacter, PSB, VAM and Azospirillum enhanced vine vigour, chlorophyll content, reproductive performance and cluster development. The interaction of moderate pruning with RDF (75%) + Azotobacter + PSB + VAM + Azospirillum (P_2B_2) produced the best vegetative growth, flowering, fruit set, average cluster number and average berries per cluster, while moderate pruning combined with RDF (100%) + Azotobacter + PSB + VAM (P_2B_1) recorded the highest cluster weight and yield. Therefore, moderate pruning integrated with biofertilizer application can be recommended as a sustainable vineyard management practice for improving productivity and maintaining efficient nutrient use in grape cv. Arka Kanchan under Prayagraj agro-climatic conditions.

Acknowledgement

The author expresses sincere gratitude to the Head of the Department of Horticulture NAI, SHUATS, Prayagraj, (U.P.) for their invaluable support and assistance.

Conflict of interest: The authors declare that they have no conflict of interest.

References

- Al-Doori, M.F. and Hussein S.A. (2025). Effect of pruning and fertilization with biofertilizer (*mycorrhiza*) on some growth characteristics and yield of grape vines (*Vitis vinifera* L.) cv. Francys. *IOP Conference Series: Earth and Environmental Science*, **1487**, 012061.
- Atak, A. (2024). Climate change and adaptive strategies on viticulture (*Vitis* spp.). *Open Agriculture*, **9**, 20220258.
- Bouyoucos, G.J. (1962). Hydrometer method improved for making particle size analysis of soils. *Agronomy Journal*, **54**, 464–465.
- Chalak, S.U. (2008). *Effect of different levels of pruning on*

- various wine grape varieties for yield and quality (Master's thesis). Mahatma Phule Krishi Vidyapeeth, Rahuri.
- Chhonkar, P.K. (2008). Organic farming and its relevance in India. In *Organic agriculture* (5–33). Indian Society of Soil Science.
- Chougule, R.A. (2004). *Studies on sub-cane pruning and cycocel application in relation to canopy management in grapes* (Master's thesis). Mahatma Phule Krishi Vidyapeeth, Rahuri.
- Dhaliwal, H.S., Banke A.K., Sharma L.K. and Bali S.K. (2013). Impact of pruning practices on shoot growth and bud production in kinnow (*Citrus reticulata* Blanco) plants. *Journal of Experimental Biology and Agricultural Sciences*, **1**.
- Dutta, P., Maji S.B. and Das B.C. (2009). Studies on the response of biofertilizers on growth and productivity of guava. *Indian Journal of Horticulture*, **66**(1), 39–42.
- El-Khayat, H.M. and Abdel Rehiem M.A. (2013). Improving mandarin productivity and quality by using mineral and bio-fertilization. *Alexandria Journal of Agricultural Research*, **58**(2), 141–147.
- Godage, S.S., Parekh N.S., Nehete D.S. and Jagtap V.M. (2013). Influences of chemical and biofertilizers on growth, flowering, fruit yield and quality of guava (*Psidium guajava* L.) cv. Allahabad Safeda. *Bioinfolet*, **10**(2A), 480–485.
- Gomez, K.A. and Gomez A.A. (1984). *Statistical procedures for agricultural research* (2nd ed.). John Wiley and Sons.
- Goswami, A.K., Lal S. and Misra K.K. (2012). Integrated nutrient management improves growth and leaf nutrient status of guava cv. Pant Prabhat. *Indian Journal of Horticulture*, **69**(2), 168–172.
- Hussein, F.A., Wafaa M.H., Hamed M.E. and Eman A.A. (2016). Safe methods for weed control in fruit crops: Challenges and opportunities. *Der Pharma Chemica*, **8**(5), 325–339.
- Indian Council of Agricultural Research. (2011). *Handbook of agriculture*. ICAR.
- Ingle, H.V., Zambre S.G. and Shinde B.B. (2005). Effect of severity of pruning on growth, yield and quality of old acid lime trees. *Agricultural Science Digest*, **25**(2), 127–129.
- Jackson, M.L. (1967). *Soil chemical analysis*. Prentice Hall of India.
- Jackson, M.L. (1973). *Soil chemical analysis*. Prentice Hall of India.
- Khadatkar, A., Mathur S.M. and Gaikwad B.B. (2018). Automation in transplanting: A smart way of vegetable cultivation. *Current Science*, **115**(10), 1884–1892.
- Khan, M.A.A. and Hameedunnisa B. (2007). Effect of organic, inorganic and biofertilizer on plant growth and chlorophyll content of acid lime (*Citrus aurantifolia* Swingle). *The Asian Journal of Horticulture*, **2**(1), 161–165.
- Kohale, V.S., Kulkarni S.S., Ranpise S.A. and Garad B.V. (2013). Effect of pruning on fruiting of Sharad Seedless grapes. *Bioinfolet*, **10**(1B), 300–302.
- Kumar, H., Katiyar P.N., Kumar A., Singh and Rajkumar B.V. (2014). Effect of different pruning severity on growth and yield of ber (*Zizyphus mauritiana* Lamk.) cv. Banarsi Karaka. *International Journal of Current Microbiology and Applied Sciences*, **3**(5), 935–940.
- Mandal, K.K., Rajak A., Debnath S. and Hasan M.A. (2013). Integrated nutrient management in aonla cv. NA-7 in the red lateritic region of West Bengal. *Journal of Crop and Weed*, **9**(1), 121–123.
- Mani, S., Meena M.L., Kumar V. and Ram R.B. (2013). Impact of integrated nutrient management on growth and yield of phalsa. *Environment and Ecology*, **31**(2B), 898–903.
- Morris, J., Main G., Threlfall R. and Striegler K. (2009). Initial response of 'Concord' and 'Sunbelt' grapes to pruning and fruit thinning. *HortTechnology*, **19**(2), 368–378.
- Olsen, S.R., Cole C.V., Watanabe F.S. and Dean L.A. (1954). *Estimation of available phosphorus in soils by extraction with sodium bicarbonate* (USDA Circular No. 939). United States Department of Agriculture.
- Ram, R.A. and Pathak R.K. (2007). Integration of organic farming practices for sustainable production of guava. *Acta Horticulturae*, **735**, 357–363.
- Shaban, A.E.A. and Haseeb G.M.M. (2009). Effect of pruning severity and spraying some chemical substances on growth and fruiting of guava trees. *American-Eurasian Journal of Agriculture and Environmental Science*, **5**(6), 825–831.
- Shahein, M.F.M., Abd El-Motty E.Z. and Fawzi M.I.F. (2010). Effect of pruning, defoliation and nitrogen fertilization on growth, fruit set and quality of Abdel-Razik Annona cultivar. *Nature and Science*, **8**(12), 281–287.
- Sharaf, M.M., Bakry K.A. and El-Gioushy S.F. (2011). The influence of some bio and organic nutritive addenda on growth, productivity, fruit quality and nutritional status of Washington navel orange trees. *Egyptian Journal of Applied Sciences*, **26**(9), 135–140.
- Sharma, A. and Bhatnagar P. (2014). Effect of integrated nutrient management on growth attributes in custard apple cv. Arka Sahan. *Progressive Horticulture*, **46**(2), 227–231.
- Sharma, A., Bhatnagar P. and Jain M.C. (2014). Effect of integrated nutrient management on growth attributes in custard apple cv. Arka Sahan. *The Asian Journal of Horticulture*, **9**(1), 43–47.
- Shukla, S.K., Adak T., Singha A., Kumar K., Singh V.K. and Singh A. (2014). Response of guava trees (*Psidium guajava* L.) to soil applications of mineral and organic fertilizers and biofertilisers under conditions of low fertile soil. *Journal of Horticultural Research*, **22**(2), 105–114.
- Singh, J.K., Singh D.K. and Singh H.K. (2014). Studies on integrated nutrient management of vegetative growth, fruiting behaviour and nutrient status of leaves and soil of bael (*Aegle marmelos* Correa) orchard cv. Narendra

- Bael-9. *The Asian Journal of Horticulture*, **9(2)**, 421–425.
- Singh, V., Dashora L.K., Rathore R.S. and Meena C.L. (2007). Flowering and yield of citrus as influenced by various organic and inorganic sources. *Current Agriculture*, **31(1–2)**, 67–71.
- Soorianathasundaram, K., Kumar R.K. and Shanthi H. (2000). Influence of organic nutrition on the productivity of banana cv. Nendran. *South Indian Horticulture*, **45**, 109–114.
- Somkuwar, R.G. and Ramteke S.D. (2008). Effect of shoot orientation on growth, biochemical changes and fruitfulness in Thompson Seedless (*Vitis vinifera* L.) grapes. *Journal of Plant Sciences*, **3(2)**, 182–187.
- Subbiah, B.V. and Asija G.L. (1956). A rapid procedure for the determination of available nitrogen in soils. *Current Science*, **25**, 259–260.
- Tangolar, S., Tangolar S., Alkan Torun A., Tarim G., Ada M., Aydin O. and Kaçmaz S. (2019). The effect of microbial fertilizer applications on grape yield, quality and mineral nutrition of some early table grape varieties. *Selcuk Journal of Agriculture and Food Sciences*, **33(2)**, 62–66.
- Vijayalakshmi, T., Kavitha C., Shanmugasundaram K.A. and Muthuvel I. (2022). Effect of biofertilizers on yield and quality attributes of grape cv. Muscat Hamburg. *Biological Forum – An International Journal*, **14(4a)**, 238–241.
- Walkley, A. and Black I.A. (1934). An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science*, **37**, 29–38.