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Synergistic influence of rootstock and cane regulation on biomass accumulation in wine grapes under semi-arid conditions

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Abstract
An investigation was conducted to know the influence of rootstock and cane regulation on growth, yield, and quality of wine grapes during 2022-2024 at the grape orchard, MHREC-Block J1, University of Horticultural Sciences, Bagalkot, located in the northern dry zone of Karnataka. The experiment was laid out in a split-split plot design with two rootstocks (Dogridge and 110 R), five wine grape cultivars (Cabernet Sauvignon, Medica, Shiraz, Sauvignon Blanc, and Chenin Blanc), and three cane regulation levels (Control, 36 canes/vine, and 24 canes/vine). Observations were recorded for fresh and dry weight of cane after foundation pruning. Results revealed that rootstock 110 R significantly outperformed Dogridge in both fresh (1540.26 g) and dry weight (1113.43 g) of cane. Among varieties, Medica recorded the highest fresh (1461.07 g) and dry weight (1071.66 g), significantly higher than others. Cane regulation of 24 canes per vine (C_3) yielded superior fresh (1271.02 g) and dry weight (945.18 g), followed by 36 canes per vine (C_2), which was on par with Control. The interaction of 110 R × Medica × 24 canes per vine recorded the highest fresh (1904.30 g) and dry weight (1182.56 g) of cane, significantly surpassing other combinations. The improvement in growth parameters under these treatments is attributed to enhanced root system efficiency, better nutrient and water uptake, optimized canopy load, and superior varietal sink strength. These findings suggest that the synergistic effect of suitable rootstock, high-performing cultivar, and optimal cane regulation improves biomass accumulation, thereby enhancing vine vigour and potential productivity under semi-arid viticultural conditions.

Keywords: Wine grapes, rootstock, cane regulation, biomass, Medica, 110 R, canopy management

Introduction
Wine grape production plays a vital role in the global wine industry, with regions like Karnataka contributing to India's emerging wine sector. The growth, yield, and quality of wine grapes are influenced by various agronomic practices, with rootstock selection and canopy management being two crucial factors. Rootstock selection affects vine growth, nutrient uptake, and water absorption, which ultimately impacts productivity, while proper cane regulation helps in optimizing grape yield and quality. In regions with challenging climatic conditions, such as Karnataka's northern dry zone, understanding the interplay between rootstock and cane regulation is essential to enhancing grapevine performance.

The northern dry zone of Karnataka presents a unique environment for viticulture, characterized by warm temperatures and low annual rainfall, requiring tailored vineyard management practices. As the region's wine grape industry continues to grow, there is an increasing need for effective strategies to optimize vine growth and grape quality. This study explores the influence of rootstock and cane regulation on the growth, yield, and quality of wine grapes in this agro-climatic zone, aiming to provide valuable insights for vineyard management. By examining how different rootstocks and cane regulation levels affect grapevine performance, the research seeks to contribute to sustainable viticulture practices and improve grape quality and yield in the region.

Materials and Methods

The present study on "Influence of Rootstock and Cane Regulation on Growth, Yield, and Quality of Wine Grapes" was conducted during 2022-2024 at the grape orchard, MHREC-Block J1, University of Horticultural Sciences, Bagalkot. The experimental site is situated at 16° 9' N latitude and 75° 37' E longitude with an altitude of 542 m in the northern dry zone of Karnataka (Zone-3). The climate is warm and dry, benefiting from both southwest and northeast monsoons, with an average annual rainfall of 552 mm. The minimum and maximum temperatures recorded over the experimental period were 23.1 °C and 31.28 °C, respectively, with relative humidity levels of 80% (morning) and 35.35% (afternoon). The experiment was conducted using a split-split plot design with 30 treatments, replicated three times. Vine spacing was maintained at 9 × 4 feet, ensuring adequate growth and data collection. The main treatments included two rootstocks (T_1: Dogridge and T_2: 110 R), while the sub-treatments consisted of five wine grape cultivars (V_1: Cabernet Sauvignon, V_2: Medica, V_3: Shiraz, V_4: Sauvignon Blanc, and V_5: Chenin Blanc). Cane regulation was considered as the sub-sub treatment, with three levels: C_1: Control, C_2: 36 canes per vine (1 cane per sq. ft), and C_3: 24 canes per vine (1 cane per 1.5 sq. ft).

Observations were recorded across growth, yield, and quality parameters. Growth parameters included fresh and dry weight of biomass after foundation pruning. Fresh weight of pruned canes was measured using a digital weighing balance immediately after pruning, while dry weight was recorded after oven drying at 65°C until a constant weight was obtained. Yield and quality parameters were evaluated as per standard procedures. Data collection was systematically performed from randomly selected vines within each replication to ensure accuracy in treatment effects. The study aimed to assess the impact of rootstock and cane regulation on vine growth, productivity, and grape quality under the agro-climatic conditions of Bagalkot.

Results and Discussion

Fresh Weight of Cane

The results are presented in Table 1. The fresh weight of cane was significantly influenced by rootstock, variety, and cane regulation. In pooled data, rootstock 110 R recorded a significantly higher fresh weight of cane (1540.26 g) compared to Dogridge (922.71 g). The increase in fresh weight of cane in 110 R could be attributed to its superior root system, which enhances nutrient uptake, water absorption, and hormonal signalling such as cytokinin and auxin translocation, promoting vigorous vegetative growth and biomass accumulation. These findings align with Chaurasiya and Singh (2017), who reported a significant increase in fresh weight of cane (452.32 g) in grapevines grafted onto 110 R, highlighting its contribution to improved rooting behaviour and photosynthetic activity. Among varieties, Medica recorded the highest fresh weight of cane (1461.07 g), significantly surpassing other varieties, followed by Shiraz (1353.96 g) and Cabernet Sauvignon (1249.72 g), which were on par with each other. The lowest fresh weight was recorded in Chenin Blanc (974.38 g). The superior performance of Medica in fresh weight might be attributed to its efficient carbon assimilation, photosynthate partitioning, and elevated sink strength, which favour cane development. Cane regulation also played a crucial role, with 24 canes per vine (1271.02 g) recording a significantly higher fresh weight than Control (1189.72 g), followed by 36 canes per vine (1233.72 g), which was on par with Control. The increased fresh weight under 24 canes per vine could be due to optimal vine load management, reducing intraplant competition for resources and enhancing photosynthetic efficiency, nutrient remobilization, and water use efficiency. Similar findings were reported by Thoke (2024), where 'Thompson Seedless' exhibited the highest fresh weight (2.23 kg/vine) under a reduced number of canes per vine, highlighting the influence of balanced canopy load on biomass production

Interaction effects were significant, with 110 R × Medica × 24 canes per vine recording the highest fresh weight of cane (1904.30 g), significantly outperforming other combinations, followed by 110 R × Medica × 36 canes per vine (1882.28 g), which was on par with 110 R × Cabernet Sauvignon × 24 canes per vine (1632.15 g). The synergistic integration of rootstock vigour, varietal metabolic efficiency, and balanced canopy management contributed to the superior performance of this combination. These findings align with Nanjappanavar *et al.* (2024) [2], who observed that while individual cane regulation treatments showed no significant differences, pooled data indicated that 36 canes per vine (24 canes per vine) recorded the highest fresh weight (2.58 kg/vine) after foundation bud pruning, emphasizing the role of optimal canopy regulation in enhancing biomass accumulation and resource utilization.

Dry Weight of Cane

The dry weight of cane differed significantly among rootstocks, varieties, and cane regulation treatments. In pooled data, rootstock 110 R recorded a significantly higher dry weight of cane (1113.43 g) compared to Dogridge (716.19 g). The increase in dry weight of cane in 110 R can be attributed to its superior root architecture, which facilitates enhanced nutrient uptake, efficient water absorption, and improved hormonal signalling, leading to increased vegetative growth and higher biomass accumulation. This is consistent with Chaurasiya and Singh (2017), who reported a significant increase in dry weight of cane (210.87 g) in grapevines grafted onto 110 R, reinforcing the role of rootstock-mediated physiological advantages in biomass production.

Among varieties, Medica recorded the highest dry weight of cane (1071.66 g), significantly higher than all other varieties, followed by Shiraz (1003.02 g) and Cabernet Sauvignon (933.31 g), which were on par with each other. The lowest dry weight was recorded in Chenin Blanc (734.53 g). The superior performance of Medica in dry weight could be attributed to its efficient photosynthate allocation, improved metabolic efficiency, and greater sink strength, favouring cane biomass accumulation. Cane regulation also influenced dry weight, with 24 canes per vine (945.18 g) recording significantly higher values compared to Control (883.21 g), followed by 36 canes per vine (916.04 g), which was on par with Control. The higher dry weight under 24 canes per vine may be due to the optimal balance between vegetative growth and vine load, reducing intraplant competition and improving nutrient and water use efficiency. Similar findings were reported by Thoke (2024), where 'Thompson Seedless' recorded the highest dry weight (1.38 kg/vine) under optimal cane load conditions, emphasizing the role of vine management in enhancing dry matter accumulation.

The interaction of 110 R, Medica, and 24 canes per vine resulted in the highest dry weight of cane (1182.56 g), significantly surpassing other treatment combinations, followed by 110 R × Medica × 36 canes per vine (1156.80 g), which was on par with 110 R × Cabernet Sauvignon × 24 canes per vine (1113.43 g). The superior performance of this interaction is likely due to the combined effect of rootstock vigor, varietal metabolic

efficiency, and balanced canopy management, which together enhance biomass production. This finding aligns with Nanjappanavar *et al.* (2024) [2], who reported that while individual treatments did not show significant differences, the combination of 36 canes per vine (24 canes per vine) recorded the highest dry weight (1.56 kg/vine) after foundation bud pruning, highlighting the importance of optimizing vine load to maximize cane biomass and overall vine productivity.

The study revealed that rootstock choice and cane regulation significantly impact wine grape performance in Karnataka's northern dry zone. Rootstock 110 R outshone Dogridge due to its superior nutrient uptake and vigor. Medica recorded the highest biomass, reflecting efficient resource utilization. Regulating vines to 24 canes improved cane weights by optimizing growth balance. The combination 110 R × Medica × 24 canes proved most effective, highlighting the synergy of rootstock vigor, varietal efficiency, and canopy management.

Table 1: Influence of rootstock and cane regulation on cane biomass after foundation pruning in wine grape varieties

Treatment	Fresh weight of cane (g)			Dry weight of cane (g)		
	2023	2024	Pooled	2023	2024	Pooled
Rootstocks (R)						
R_1-Dogridge	964.47	880.95	922.71	758.47	673.91	716.19
R_2-110-Richter	1618.38	1462.14	1540.26	1152.94	1073.92	1113.43
S. Em ±	3.02	2.90	1.23	5.93	3.95	2.20
CD at 5%	18.39	17.65	7.50	36.10	24.06	13.36
Varieties (V)						
V_1-Cabernet Sauvignon	1322.11	1177.32	1249.72	974.31	892.31	933.31
V_2-Medika	1530.79	1391.36	1461.07	1114.31	1029.02	1071.66
V_3-Shiraz	1413.80	1294.12	1353.96	1041.28	964.76	1003.02
V_4-Sauvignon Blanc	1169.03	1067.58	1118.31	875.71	787.35	831.53
V_5-Chenin Blanc	1021.40	927.36	974.38	772.91	696.16	734.53
S. Em ±	27.16	21.72	12.76	18.34	15.94	13.61
CD at 5%	81.43	65.11	38.26	54.97	47.80	40.79
Canes (C)						
C_1-Control	1241.78	1137.66	1189.72	927.02	839.40	883.21
C_2-36 Canes	1298.32	1169.12	1233.72	958.60	873.49	916.04
C_3-24 Canes	1334.18	1207.87	1271.02	981.48	908.87	945.18
S. Em ±	20.63	18.75	14.18	14.04	17.65	12.04
CD at 5%	58.97	53.59	40.53	40.13	50.45	34.41
Interactions (R x V x C)						
$R_1V_1C_1$	923.38	876.42	899.90	736.51	648.61	692.56
$R_1V_1C_2$	934.34	879.06	906.70	755.96	694.04	725.00
$R_1V_1C_3$	986.02	889.67	937.85	775.04	707.24	741.14
$R_1V_2C_1$	1089.25	968.97	1029.11	849.57	757.40	803.49
$R_1V_2C_2$	1103.90	998.44	1051.17	862.07	775.01	818.54
$R_1V_2C_3$	1182.60	1044.56	1113.58	896.99	813.33	855.16
$R_1V_3C_1$	1021.49	909.89	965.69	803.16	712.89	758.03
$R_1V_3C_2$	1059.95	942.49	1001.22	828.22	745.44	786.83
$R_1V_3C_3$	1080.80	951.66	1016.23	839.02	751.28	795.15
$R_1V_4C_1$	879.02	822.80	850.91	695.20	610.14	652.67
$R_1V_4C_2$	884.02	832.52	858.27	716.37	632.46	674.42
$R_1V_4C_3$	900.79	872.64	886.72	730.00	635.49	682.75
$R_1V_5C_1$	749.14	720.40	734.77	586.19	497.15	541.67
$R_1V_5C_2$	834.21	722.29	778.25	618.86	531.14	575.00
$R_1V_5C_3$	838.15	782.45	810.30	683.83	597.09	640.46
$R_2V_1C_1$	1653.43	1435.97	1544.70	1156.44	1047.14	1101.79
$R_2V_1C_2$	1706.73	1447.27	1577.00	1200.33	1113.26	1156.80
$R_2V_1C_3$	1728.77	1535.54	1632.15	1221.56	1143.56	1182.56
$R_2V_2C_1$	1827.56	1744.44	1786.00	1301.31	1219.92	1260.62
$R_2V_2C_2$	1986.45	1778.11	1882.28	1366.95	1284.69	1325.82
$R_2V_2C_3$	1994.99	1813.61	1904.30	1408.96	1323.75	1366.36
$R_2V_3C_1$	1737.64	1613.93	1675.79	1250.74	1176.33	1213.53
$R_2V_3C_2$	1788.49	1669.95	1729.22	1255.78	1189.70	1222.74
$R_2V_3C_3$	1794.46	1676.76	1735.61	1270.78	1212.92	1241.85
$R_2V_4C_1$	1349.05	1216.41	1282.73	990.81	894.94	942.88
$R_2V_4C_2$	1441.68	1320.06	1380.87	1058.13	931.19	994.66
$R_2V_4C_3$	1559.64	1341.06	1450.35	1063.72	1019.87	1041.80
$R_2V_5C_1$	1187.90	1067.40	1127.65	900.31	829.51	864.91
$R_2V_5C_2$	1243.38	1100.96	1172.17	923.33	837.93	880.63
$R_2V_5C_3$	1275.59	1170.69	1223.14	924.93	884.15	904.54
S. Em ±	65.25	59.29	44.84	44.39	55.82	38.07
CD at 5%	186.49	169.45	128.16	126.89	159.53	108.81

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