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Growth Performance of Low Chilling Varieties of Apple (*Malus x domestica* Borkh.) under the Influence of Different Nutrient Levels in Assam, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation was undertaken to evaluate the growth characters and leaf nutrient content of low-chilling apple *(Malus x domestica* Borkh.) under the effect of different nutrient levels in Assam. Three low-chilling varieties viz. HRMN-99, Dorsett Golden and Anna were grown for this purpose subjected to different nutrients levels comprising of FYM applied alone or in combination with NPK doses. Obtained results revealed that HRMN-99 registered the highest significant plant height (179.76 cm), stem girth (9.91 cm), leaf area (63.34 cm^2) and leaf area index (2.42) at the end

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of season. Amongst various nutrient levels, the application of 5 kg FYM+ 150 g urea+ 210g SSP+ 120 g MOP/plants showed superior performance in terms of plant height (192.03 cm), stem girth (11.30 cm), number of branches (17.25), leaf area (69.38 cm^2) and leaf area index (2.61). Analysis of leaf nutritional status revealed that the variety HRMN-99 and nutrient application of 5 kg FYM+ 150 g urea+ 210g SSP+ 120 g MOP/plants showed impressive results in terms of leaf N, P, K, Ca and Mg. Thus, the variety HRMN-99 at nutrient level of 5 kg FYM+ 150 g urea+ 210g SSP+ 120 g MOP/plant proved to be promising for apple cultivation under Assam condition.

Keywords: Varieties; low-chilling; growth; Assam; nutrient level.

1. INTRODUCTION

Apple (*Malus x domestica* Borkh.) is a significant fruit crop of the Rosaceae family growing in the temperate regions of the world. It was believed to be originated from *Malus siversii*, one of its progenitor species, in the Central Asiatic region dating back to more than 4000 years ago [1]. Apple finally arrived in India during 1865 with its introduction to the Kullu Valley of Himachal Pradesh by the Captain Lee. China is the world's leading producer of apple. In India, it is mostly grown in Jammu and Kashmir, Himachal Pradesh, hills of Uttar Pradesh and Uttarakhand and to a limited extend in the north-eastern states of Arunachal Pradesh, Nagaland, Sikkim, Meghalaya and Manipur and southern regions of Deccan Plateau and Nilgiri hills. Majority of the apple cultivars require a minimum chilling requirement varying from 1000-1500 hours below 7°C for breaking dormancy which can be easily achieved in the temperate apple growing regions. Low chilling cultivars have adaptive potential in the tropical and subtropical areas due to their chilling requirement of less than 300 hours (below 7°C) for effective flowering and fruiting. Anna, HRMN-99, Tropical Beauty, Early Fuji, Tamma, Neomi, Parlin's Beauty, Michal, Dorsett Golden etc. are few examples of the low-chilling apple varieties.

Assam lies in the sub-tropical zone with latitude 24°07' N to 28°00' N and longitude 89°42' E to 96°02' E. The region experiences temperature ranging from 5°C to 32°C and heavy annual rainfall in the range between 1500 mm to 3750 mm mainly due to the southwest monsoon [2]. The cool season generally prevails from mid-November to mid-February and is marked by brief showers and misty mornings and afternoons. Taking into account the agro-climatic condition of Assam, there exists the possibility of growing the low-chilling varieties of apple in the region. Apple cultivation in these non- traditional areas will benefit the growers due to its early ripening behavior and high market value. The evaluation of the varieties with respect to growth performance is essential to study under a particular climatic condition. Furthermore, there is no published record on low-chilling varieties of apple under Assam conditions. Keeping in view these aspects, the present investigation was undertaken in an attempt to study the growth performance of low chilling varieties of apple under the climatic conditions of Assam.

2. MATERIALS AND METHODS

The present study was conducted at the Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat (located at 26˚45' N latitude, 94˚12' E longitude and at an altitude of 87 m above mean sea level) during the period 2022-23. The experiment was laid out in a factorial randomized block design with four replications. For this purpose, three low-chilling varieties, viz. V_1 (HRMN-99), V_2 (Dorsett Golden) and V_3 (Anna) were planted and subjected to five different nutrient levels, viz. N_1 [FYM 5 kg/plant (Control)], N_2 (5 kg FYM+ 50 g urea+ 70g SSP+ 40 g MOP/plant), N_3 (5 kg FYM+ 100 g urea+ 140g SSP+ 80 g MOP/plant), N_4 (5 kg FYM+ 150 g urea+ 210g SSP+ 120 g MOP/plant) and N_5 (5 kg FYM+ 200 g urea+ 280g SSP+ 160 g MOP/plant) giving rise to 15 treatment combinations. The plants were planted on 10th May, 2022 in pits of size 1m x 1m x 1m each spaced at 3 meters apart covering an experimental area of 540 m^2. The entire amount of FYM was applied during pit filling and incorporated before planting of the seedlings while the NPK sources were applied in two split doses. The sources of N, P_2O_5 and K_20 used were urea, SSP and MOP, respectively. The first split dose was applied just after planting while the remaining half was applied in September as per treatment allocation.

The various plant growth parameters like height, stem girth, number of branches, leaf area and leaf area index were recorded using the standard procedures at the end of season. The plant height was measured from the ground level up to the highest terminal point on the leaf using a measuring tape and expressed in centimeter. The girth (cm) of the stem was measured at 5 cm above the graft union with the help of Vernier calipers. The number of branches per plant were also recorded at the end of season. The leaf area (cm^2) was recorded by randomly collecting three fully developed leaf samples from each plant and measured with the help of leaf area meter. Leaf Area Index (LAI) was determined from the total area of leaves divided by the ground area covered by the plant [3]. To determine leaf nutrient content, the green non- diseased leaf samples were collected from all the replications of each of the treatments. Data was recorded at 30 and 45 days after application of treatments. The leaf samples were washed properly, dried and then crushed, ground and stored in sealed polythene bags. The nitrogen content was determined using modified Kjeldahl method, phosphorus was estimated using Vanadomolybdate yellow color method and potassium by flame photometer method as described by Jackson [4]. Leaf calcium and magnesium content was estimated by complexometric titration (EDTA method) as proposed by Chapman [5]. Data recorded were subjected to analysis of variance (ANOVA) as per the procedures given by Panse and Sukhatme [6].

3. RESULTS AND DISCUSSION

3.1 Effect of Variety and Nutrient Level on Plant Growth

The plant growth characters differed significantly under the influence of varieties (Table 1). Highest significant differences were recorded by the variety HRMN-99 for plant height (179.76 cm), stem girth (9.91 cm), leaf area (63.34 cm^2) and leaf area index (2.42) which was statistically identical with the variety Dorsett Golden whereas the lowest of these parameters were exhibited by the variety Anna. However, the highest number of branches (14.65) were produced by the variety V_2 which was statistically at par with V_1. The boost in the growth characters can be attributed to the genetical superiority of the variety compared to the other two varieties. Similar records of genetical variability in the growth performance were presented by Firde *et al*. [7] and Menegatti *et al.* [8] in peach.

Data pertaining to Table 1 shows that the growth of the plant was significantly affected by different nutrient levels. The maximum plant height (192.03 cm), stem girth (11.30 cm), number of branches (17.25), leaf area (69.38 cm^2) and leaf area index (2.61) were exhibited under the nutrient level N_4 (5 kg FYM+ 150 g urea+ 210g SSP+ 120 g MOP/plant) which was closely followed by the nutrient level N_5 (5 kg FYM+ 200 g urea+ 280g SSP+ 160 g MOP/plant) and the lowest was obtained under the control treatment N_1. Nitrogen, phosphorus and potassium are essential for the plant growth and development. The increase in growth in the higher nutrient levels can be attributed to the proper root development due to the increased availability and uptake of nutrients [9]. This will further contribute to faster cell differentiation and elongation and subsequently the growth as corroborated by Villasurda and Baluyut [10] and Yadav *et al*. [11]. The sudden decline in the growth parameters at the highest nutrient level may be due to attaining the optimum concentration at N_4 after which plants become unresponsive to the excess of nutrients supplied. The results were in line with the findings of Anusha *et al*. [12] and Mensah *et al.* [13].

The interaction of variety and nutrient level also differed significantly for all the growth characters. The highest significant plant height (209.55 cm) was recorded under V_1N_4 which was statistically identical to V_1N_5, V_2N_3 and V_2N_4. Similarly, the highest stem girth (12.22 cm) was observed under V_1N_4 which was closely followed by V_2N_4 both being at par. However, the maximum number of branches (19.25) were exhibited by the treatment V_2N_4 closely followed by V_1N_4 and V_2N_5. The highest leaf area (71.50 cm^2) was obtained under the treatment V_1N_4 which was at par with V_1N_5, V_2N_4, V_3N_4, V_3N_5 and V_2N_5.Similarly, the maximum leaf area index (2.83) was exhibited by the treatment V_1N_4 which was statistically similar with V_1N_5, V_2N_4 and V_2N_5. The lowest of all the growth parameters were however recorded under the treatment V_3N_1.

3.2 Effect of Variety and Nutrient Level on Leaf Nutrient Concentration

Leaf nutrient content of the apple plants varied significantly due to variety (Table 2). Significantly highest leaf nitrogen (2.39% and 2.27%), phosphorus (0.25% and 0.22%), potassium (1.75% and 1.71%), calcium (1.45% and 1.65%) and magnesium (0.32% and 0.39%) content was observed in HRMN-99 at 30 and 45 DAT, respectively closely followed by the variety Dorsett Golden while the lowest of these nutrients was observed in the variety Anna. This may be possibly due to the genetic variation which generated different nutrient uptake capacity in the apple varieties. Similar findings were published by Neilsen *et al*. [14] in apple and Fatma *et al*. [15] in plum.

Data presented in Table 2 clearly shows that the nutrient levels significantly affected the leaf nutrient concentrations. The highest leaf N (2.66% and 2.50%), P (0.29% and 0.25%) and K (1.84% and 1.83%) content was obtained under the treatment N_4 which was at par with N_5. However, the maximum concentration of leaf Ca (1.48% and 1.69%) and Mg (0.37% and 0.43%) was observed under the treatment N_3 which was at par with N_4. The lowest of all the leaf nutrient contents was recorded under the control treatment without any NPK dosage. The increase in the leaf N with the higher nutrient levels may be attributed to the higher uptake of nitrogen from the root zone which will translocate and accumulate in the leaves due to its high mobility. Similar findings were observed by Rubio *et al*. [16] in low-chilling peach cultivars. Likewise, the increased uptake of phosphorus by the plant due to the increased application of phosphatic fertilizer as well as FYM will enhance the phosphorus content in the leaves. The increase in potassium content in the leaves may be ascribable to the increased uptake due to the concentration gradient of potassium ions maintained between the root and the soil solution. The results were in agreement with the findings of Kaith and Kumar [17] in apple. The variation in leaf Ca and Mg was observed due to the synergistic effect of N on Ca and Mg uptake as confirmed by the reports of Raese and Drake [18] and antagonistic effect of K on Ca and

Table 1: Plant growth as influenced by variety and nutrient level

Treatments	Plant Height (cm)	Stem Girth (cm)	Number of Branches	Leaf Area (cm^2)	Leaf Area Index
Variety					
V_1	179.76	9.91	13.90	63.34	2.42
V_2	177.48	9.18	14.65	60.90	2.41
V_3	161.53	7.95	10.85	59.62	2.04
SEd (±)	3.70	0.42	0.39	1.49	0.09
C.D. (P=0.05)	7.46	0.86	0.79	3.01	0.18
Nutrient level					
N_1	148.94	6.25	7.25	50.32	1.86
N_2	161.40	8.05	11.42	57.73	2.12
N_3	177.64	9.26	14.08	61.59	2.33
N_4	192.03	11.30	17.25	69.38	2.61
N_5	184.59	10.20	15.67	67.40	2.53
SEd (±)	4.77	0.55	0.51	1.93	0.12
C.D. (P=0.05)	9.63	1.10	1.02	3.89	0.23
Interaction					
V_1N_1	155.08	8.73	8.00	57.68	2.08
V_1N_2	162.13	9.04	11.25	58.80	2.13
V_1N_3	174.03	9.28	14.50	59.03	2.38
$V1N_4$	209.55	12.22	18.75	71.50	2.83
V_1N_5	198.00	10.30	17.00	69.70	2.71
V_2N_1	151.25	6.54	8.25	49.73	2.22
V_2N_2	165.03	8.41	12.25	57.85	2.40
V_2N_3	194.55	9.55	16.00	63.68	2.41
V_2N_4	193.03	11.15	19.25	68.35	2.53
V_2N_5	183.53	10.23	17.50	64.88	2.48
V_3N_1	140.50	3.49	5.50	43.55	1.27
V_3N_2	157.05	6.70	10.75	56.53	1.83
V_3N_3	164.35	8.96	11.75	62.08	2.22
V_3N_4	173.50	10.52	13.75	68.30	2.48
V_3N_5	172.25	10.07	12.50	67.63	2.41
SEd (±)	8.26	0.95	0.88	3.33	0.20
C.D. (P=0.05)	16.68	1.91	1.77	6.73	0.41

Table 2. Leaf nutrient concentration as influenced by variety and nutrient level

Treatments	Leaf nitrogen (%)		Leaf phosphorus (%)		Leaf potassium (%)		Leaf calcium (%)		Leaf magnesium (%)	
	30 DAT	45 DAT	30 DAT	45 DAT	30 DAT	45 DAT	30 DAT	45 DAT	30 DAT	45 DAT
Variety										
V_1	2.39	2.27	0.25	0.22	1.75	1.71	1.45	1.65	0.32	0.39
V_2	2.30	2.14	0.24	0.21	1.69	1.67	1.37	1.60	0.31	0.38
V_3	2.21	2.07	0.19	0.16	1.63	1.56	1.35	1.48	0.27	0.33
SEd (±)	0.05	0.04	0.01	0.01	0.03	0.04	0.03	0.02	0.01	0.01
C.D. (P=0.05)	0.10	0.08	0.02	0.02	0.06	0.07	0.06	0.04	0.01	0.01
Nutrient level										
N_1	1.87	1.77	0.14	0.13	1.50	1.45	1.29	1.46	0.23	0.28
N_2	2.25	2.01	0.19	0.17	1.63	1.56	1.39	1.52	0.26	0.35
N_3	2.29	2.14	0.23	0.21	1.69	1.64	1.48	1.69	0.37	0.43
N_4	2.66	2.50	0.29	0.25	1.84	1.83	1.42	1.65	0.35	0.42
N_5	2.43	2.38	0.27	0.23	1.79	1.75	1.39	1.56	0.29	0.36
SEd (±)	0.06	0.05	0.01	0.01	0.04	0.05	0.04	0.03	0.01	0.01
C.D. (P=0.05)	0.12	0.10	0.02	0.02	0.08	0.09	0.08	0.06	0.02	0.01
Interaction										
V_1N_1	1.85	1.82	0.17	0.16	1.66	1.61	1.38	1.56	0.24	0.31
V_1N_2	2.29	2.10	0.22	0.20	1.68	1.65	1.36	1.60	0.28	0.37
V_1N_3	2.38	2.28	0.24	0.22	1.72	1.68	1.62	1.79	0.40	0.46
V_1N_4	2.80	2.66	0.32	0.29	1.87	1.86	1.45	1.66	0.38	0.44
V_1N_5	2.62	2.50	0.30	0.26	1.82	1.76	1.43	1.64	0.31	0.39
V_2N_1	1.96	1.82	0.14	0.11	1.54	1.50	1.27	1.49	0.23	0.30
V_2N_2	2.35	1.96	0.17	0.16	1.61	1.60	1.46	1.55	0.27	0.36
V_2N_3	2.24	2.10	0.26	0.24	1.71	1.69	1.49	1.72	0.39	0.45
V_2N_4	2.71	2.57	0.31	0.27	1.83	1.82	1.38	1.64	0.37	0.44
V_2N_5	2.26	2.25	0.30	0.26	1.75	1.71	1.28	1.61	0.30	0.37
V_3N_1	1.80	1.68	0.12	0.11	1.31	1.24	1.21	1.32	0.22	0.23
V_3N_2	2.10	1.96	0.17	0.15	1.59	1.44	1.34	1.40	0.24	0.33
V_3N_3	2.24	2.05	0.20	0.17	1.64	1.56	1.32	1.57	0.32	0.38
V_3N_4	2.47	2.28	0.24	0.20	1.81	1.81	1.43	1.66	0.30	0.37
V_3N_5	2.43	2.40	0.21	0.19	1.79	1.78	1.46	1.44	0.27	0.33
SEd (±)	0.11	0.09	0.02	0.02	0.07	0.08	0.07	0.05	0.01	0.01
C.D. (P=0.05)	0.21	0.17	0.04	0.04	0.14	0.16	0.14	0.10	0.03	0.02

Mg uptake as reported by Fallahi *et al*. [19]. The decreasing trend of the leaf nutrient contents after attaining the highest concentration may be attributed to the reason that increasing the nutrient level above the optimum reduces the crops' response to the nutrients as plants are unable to uptake the excess nutrients. Similar findings were reported by Fatma *et al*. [15] in plum.

The leaf nutrient content was also observed to differ significantly under the interaction effect of variety and nutrient level (Table 2). The highest significant leaf nitrogen (2.80% and 2.66%) was found under the treatment V_1N_4 at 30 and 45 DAT, respectively which was closely followed by V_2N_4, V_1N_5 and V_2N_5. Similar trend was observed in leaf phosphorus content where the highest (0.32% and 0.29%) was recorded under V_1N_4 at 30 and 45 DAT, respectively which was at par with V_2N_4, V_1N_5 and V_2N_5. The maximum potassium content (1.87% and 1.86%) was obtained in the treatment V_1N_4 which was statistically identical to V_2N_4, V_1N_5 and V_2N_5 at 30 and 35 DAT, respectively. The maximum leaf Ca (1.62% and 1.79%) was observed under V_1N_3 at

30 and 45 DAT, respectively which was at par with V_2N_3. Similarly, V_1N_3 recorded the highest magnesium content (0.40% and 0.46%) at 30 and 45 DAT respectively. The decrease in leaf N, P and K after 30 DAT can be attributed to the nutrient distribution to other plant parts throughout its vegetative cycle. However, due to the limited mobility of Ca and Mg in the phloem, the concentration of these elements increases. The idea was supported by the findings of Malik *et al*. [20] in apple.

4. CONCLUSION

From the findings of the present investigation, it can be inferred that the performance of the variety V_1 (HRMN-99) was superior in terms of most of the growth parameters under the influence of nutrient level N_4 (5 kg FYM+ 150 g urea+ 210g SSP+ 120 g MOP/plant). Also, the variety and nutrient level combination of V_1N_4 proved to be the best among all the other treatments. Therefore, the variety HRMN-99 at nutrient level of 5 kg FYM+ 150 g urea+ 210g SSP+ 120 g MOP/plant can be recommended for apple cultivation under Assam condition in its first year of plantation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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