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PERFORMANCE EVALUATION OF DIFFERENT VARIETIES OF SPINACH (*SPINACEA OLERACEA* L.)

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ABSTRACT

An experiment was conducted at Instructional Farm of Arunachal University of Studies, Namsai, and Arunachal Pradesh to evaluate the performance of five different Spinach varieties for quality, growth and yield attributes. The experiment was laid out in randomized block design (RBD) with five treatments and four replications. The five varieties used for an experiment as treatments were *viz*. T_1 (All Green), T_2 (TSC-Rama), T_3 (Hariyali), T_4 (Supriya) and T_5 (Haldibari). Spinach seeds were seeded in the second week of September. The growth attributing characters of Spinach varieties expressed in terms of days to 60 per cent germination and days to harvest was significantly the earliest in all green (48.20). The analysis revealed highly significant differences. The results showed that there was significant variation among the varieties in respect to plant height, length of leaves, leaves width, leaves area, yield per plant, yield per plot and total yield parameters. In the experiment, T_1 provided better growth, yield, and quality parameter as compared to other varieties with plant height (23.67 cm), leaves length (15.38 cm), leaves width (9.1 cm), No. of leaf (19.90), leaves area (154.53 cm^2), yield per plant (60.7g), yield per plot (2.563 kg), yield kg /ha (20.38 kg/ha), moisture content percentage (90.32%) TSS (6.73^0 Brix) ,ascorbic acid was found maximum in T_4 with average of (26.81 mg/100g) and titratable acidity % was found maximum at T_3 with (0.26%).The findings of the experiment suggested that the overall best performance was obtained by the T_1 variety compared to the other four varietal treatments for spinach cultivation in the Namsai condition.

Keywords **:** Spinach, Performance, Evaluation, Varieties, Growth, Quality, Yield and Differences.

Introduction

Spinach (*Spinacia oleracea* L.) family Chenopodiaceous with chromosome number 2n=12. It's most important leafy vegetables grown in cool season crop. It is an annual vegetable in the market and Spinach contributes plant with a short growth cycle which belongs to the substantially towards meeting this shortage. Spinach is a highly desirable leafy vegetable with good Spinach is a valuable crop for food and medicinal cooking adoptability, the edible portion of this vegetable is green tender leaf. This crop is dioeciously in nature.

The leading Spinach producing states in India are Maharashtra, West Bengal, Gujarat, Andhra Pradesh, Kerala, Tamil Nadu, Karnataka and Uttar Pradesh. It is a high nutritive value and many purposes with production of over 26 million tons on about important vitamins and minerals. Spinach-derived phytochemicals and types of Spinach varieties *viz.,* smooth leaved, crinkle bioactive are able to scavenge reactive oxygen species leaved, round leaved, semi round leaved, pointed leaved, and prevent macromolecular oxidative damage, modulate 'Savoy' type etc. Two types' proliferation, inflammation and antioxidant defiance and of spinach, green and red, are in cultivation former being also curb food intake by inducing secretion of satiety heavier in growth and bears thicker.

Winter vegetables can tolerate less than 5^{0}C and required 10^{0}C to 18^{0}c temperature. Vegetable are being mostly low in fat and carbohydrate, but high in

vitamin and minerals and dietary fibre which are required by humans for their normal growth and development. Apart from health benefits, the production of vegetables improves the economy of a country as these are very good source of income and employment. One of the main reasons to conduct this study is to identify varieties with high yield and good quality that can be adapted for cultivation in under mild tropical zone (0-200 m MSL) of Arunachal Pradesh.

The performance of varieties is highly influenced by its growing environment and management practices. Evaluation of crop varieties in a particular agro-climatic region is highly necessary to judge their performance on that region that helps to select the best types and to promote these identified types among the growers. Meanwhile, bringing in new spinach cultivars will help diversify the market and provide customers more options. Therefore, the present study will be useful in enhancing basic understanding about spinach farming and useful to investigate how Spinach perform under plains of Arunachal Pradesh. So, in this trial will be conducted to evaluate 5 spinach varieties to select best performing one with respect to earliness, quality and yield under mild tropical zone (0-200 m MSL) of Arunachal Pradesh and to encourage the local farmers to grow spinach.

Materials and Methods

A field experiment titled "Performance evaluation of different varieties of Spinach (*Spinacia oleracea* L.)" was conducted during the rabi season of 2023–2025 at the Agricultural Research Field of Arunachal University of Studies, Namsai. The experimental site is located at 27.66894°N latitude and 95.87135°E longitude, at an elevation of 156 meters above mean sea level. The region experiences a tropical climate, with summer temperatures ranging from 28°C to 40°C, winter temperatures from 10°C to 25°C, and an annual rainfall between 3500 to 4000 mm. The relative humidity averages 90% in summer and 62% in winter. The soil of the experimental site is sandy loam in texture with a pH of 6.73, slightly alkaline in nature.

The experiment was laid out in a Randomized Block Design (RBD) consisting of five spinach varieties T_1 (All Green, Genexis, Vadodara), T_2 (TSC-Rama, Tirupati Seeds Corporation, West Bengal), T_3 (Hariyali, Kalash, Jalna), T_4 (Supriya, Agro Seeds, Allahabad), and T_5 (Haldibari, Chakra, Kolkata) with four replications. The total experimental area was 20.16 m², with each plot measuring 1.12 × 0.90 m. Seeds were sown on December 2, 2024. Field preparation involved ploughing twice, followed by bed preparation to ensure proper drainage. Seeds were sown in rows spaced 15 cm apart, with 10 cm between plants. Fertilizers applied included organic cow dung during land preparation, and urea and muriate of potash in three equal splits after seed germination at 15-day intervals. Initial irrigation was provided immediately after sowing and continued three times a week for the first 10 days, then reduced based on soil moisture. Mulching with dried banana leaves followed by paddy straw was applied to retain soil moisture and suppress weed growth. Manual weeding using a khurpi was done at 20 and 40 days after sowing.

Growth attributes such as plant height, number of leaves, leaf length, leaf width, and leaf area were recorded at 15, 30, 45, and 60 days after sowing (DAS). Yield parameters included fresh and dry leaf weight, days to harvest, yield per plant, yield per plot and total yield kg per hectare. Quality parameters like moisture content, total soluble solids (TSS^0Brix), ascorbic acid, and titratable acidity were measured using standard procedures. Statistical analysis was conducted using ANOVA through OPSTAT and WASP software, and treatment differences were evaluated at the 5% significance level.

Results and Discussions

Growth parameter

Plant height (cm): The information supplied displays the measurements of plant height for several spinach varieties at different phases of development. T_1 (All Green) had the tallest plant at 15 DAS, measuring 6.5 cm. At 8.22 cm, T_2 (TSC-Rama) was the shortest. T_1 (All Green) once more displayed the highest height of 11.7 cm at 30 DAS. T_2 (TSC-Rama) was statistically comparable to T_5 with a minimum height of 8.22 cm. T_1 (All Green) recorded the highest height at 45 DAS measuring 17.44 cm. T_4 recorded the lowest height at 15.47 cm, which was statistically comparable to T_2 and T_3. T_1 (All Green) had the tallest plant at harvest, measuring 24.53 cm. At 22.78 cm, the lowest plant height measured by T_4 was statistically comparable to that of T_2 and T_3. According to the observed differences in plant height between the various spinach varieties, T_1 (All Green) grew better than the others, whereas T_2 (TSC-Rama) had the smallest plant height. At several growth phases, the differences were statistically significant; suggesting that plant height is a good predictor of vegetative growth. Furthermore, these results are consistent with those of Prasad *et al.* (2023), who found that perennial spinach types generated the tallest plants (18.16 cm), suggesting that plant height is a favourable characteristic of vegetative growth.

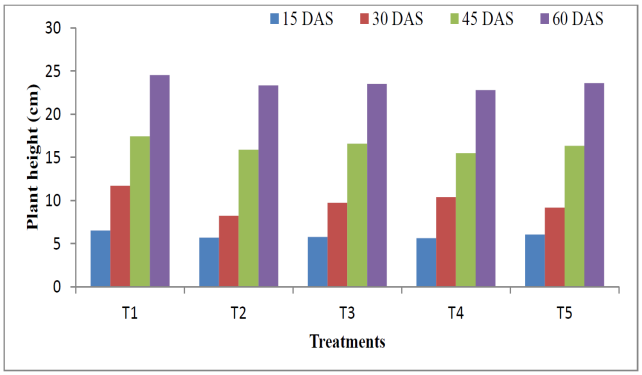

Fig. 1: Performance of different varieties of Spinach on plant height (15, 30, 45 and 60 DAS)

Leaf length (cm): At 15 DAS here the maximum leaf length was noted in the type equation. One, completely All Green, measuring 3.93 cm. T_3 (Hariyali) had the smallest leaf length, measuring 2.80 cm. 30 DAS T_1 (All Green) had the longest leaves, measuring 6.58 cm. T_2 had the smallest leaf length, measuring 5.82 cm, which was statistically comparable to T_5 and T_3. 45 DAS T_1 (All Green) had the longest leaves; measuring 13.63 cm. T_4 had the smallest leaf length, measuring 11.04 cm, which was statistically comparable to T_2 and T_3. Harvesting T_1 (All Green) had the longest leaves; measuring 15.38 cm. T_5 had the smallest leaf length, measuring 12.94 cm, which was statistically comparable to T_2 and T_3. Although their measures were statistically close at some points, the data shows that T_1 (All Green) consistently generated the longest leaves at each time point, whereas T_3 (Hariyali) and T_5 had the shortest leaf lengths. A study by Methala *et al.* (2020) found that Sathi varieties produced the longest leaves (15.52 cm), suggesting that leaf length is a good quality of vegetative growth. This suggests that variations in vegetative growth can be linked to variations in leaf length among the various varieties.

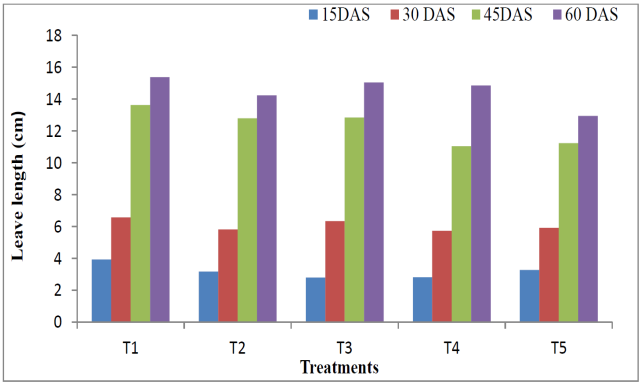

Fig. 2: Performance of different varieties of Spinach on leaf length (15, 30, 45 and 60 DAS)

Leaf width (cm): Data on leaf width over designated periods for various spinach varieties 15 DAS T_1 (All Green) had the widest leaves, measuring 2.04 cm. T_4 (Supriya) has the smallest leaf width, measuring 1.54 cm. 30 DAS T_1 (All Green) had the widest leaves, measuring 3.48 cm. T_4 (Supriya) had the smallest leaf width, measuring 3.11 cm, which was statistically comparable to T_1 and T_5 at 45 DAS. T_1 (All Green) had the widest leaves, measuring 7.10 cm. T_4 (Supriya) had the smallest leaf width, measuring 6.18 cm, which was statistically comparable to T_1 and T_2. Harvest T_1 (All Green) had the widest leaves, measuring 9.10 cm. Minimum leaf width of 7.78 cm, T_4 (Supriya) was statistically *at par* comparable to T_3 and T_5. T_1 (All Green) had the widest leaves at every interval, according to the data, and its leaf width was noticeably greater than that of other kinds. Although T_4 (Supriya) had the thinnest leaves, at some times its measures were statistically comparable to those of other kinds, such as T_3 and T_5. The results corroborate the findings of research conducted by Shadap *et al.* (2023) .They found variances in leaf width and growth among various spinach types and reported that Sathi cultivars generated the longest leaves, which is consistent with the findings here. This variance in leaf width may be a sign of variations in the kinds' vegetative health and growth traits.

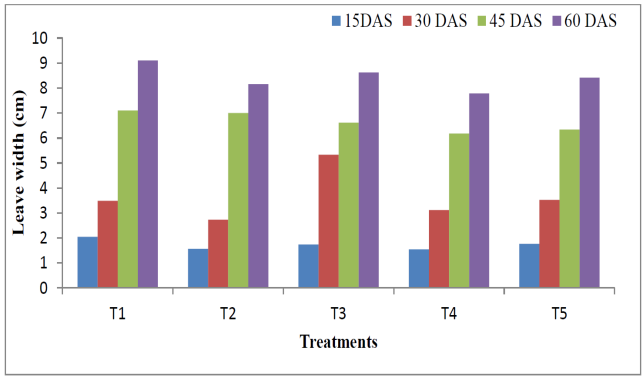

Fig. 3: Performance of different varieties of Spinach on leaf width (15, 30, 45 and 60 DAS)

Number of leaves: The information helps to understand the vegetative growth patterns and potential yield of various spinach varieties by showing how many leaves they produce at different growth stages. In comparison to T_4 (Supriya), which had the fewest leaves (2.7), T_1 (All Green) generated the most leaves (4.25) at 15 DAS, indicating greater early growth. This implies that T_1 might grow more quickly at first, which could eventually result in larger yields. T_1 maintained its lead with 8.1 leaves by 30 DAS, whereas T_4 trailed behind with 5.6 leaves, demonstrating T_1 steady growth advantage. Variations in the kinds' leaf output indicate variances in their vegetative expansion, with T_4 showing a slower rate of expansion. These results are consistent with those of Methala *et al.* (2020), who found that the Sathi variety generated the most leaves

(9.6), suggesting that leaf number is a reliable predictor of the quality of vegetative growth.

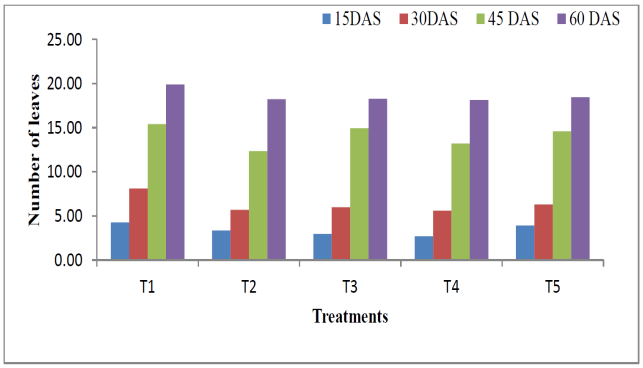

Fig. 4: Performance of different varieties of Spinach on number (15, 30, 45 and 60 DAS)

Leaf area (cm²): Crucial information about the vegetative development of spinach can be gleaned from the variance in leaf area across different spinach varieties at different stages of growth. Since leaf area directly impacts a plant's capacity to absorb light and generate energy, it is essential for photosynthesis and total plant growth. T_1 (All Green) had the biggest leaf area at 15 DAS, measuring 14.10 cm², while T_4 (Supriya) had the smallest, measuring 11.25 cm². Because of this early advantage, T_1 may grow more quickly at first, absorbing more nutrients and sunshine and accumulating more biomass. T_1 (All Green) continued to have an advantage in photosynthesis and growth at 30 DAS, as evidenced by its greater leaf area (33.30 cm^2) compared to T_4 (Supriya) (29.85 cm2). The fact that T_1 had grown to 65.40 cm² by 45 DAS and T_4 (Supriya) had grown to 59.70 cm² further highlighted T_1 (All Green) better growth. In comparison to T_4 (Supriya), which had the shortest leaf area (110.85 cm^2) at harvest, T_1 (All Green) had the biggest leaf area (154.53 cm²). The results are consistent with earlier studies by Raghavan *et al.* (2023), which found that All Green types produced the largest leaf area (37.55 cm2), suggesting that leaf area is a good characteristic of vegetative development.

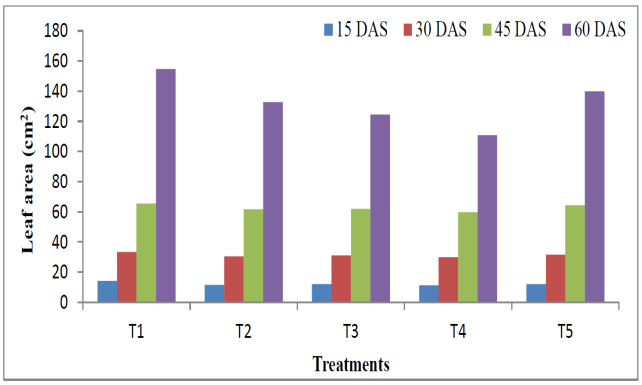

Fig. 5: Performance of different varieties of Spinach on leaf area cm^2 (15, 30, 45 and 60 DAS)

Yield attributes

Days to harvest: Among all the treatments, the T_1 (All Green) varieties took the fewest days (42.00) to harvest, followed closely by T_5 (Haldibari) with 48.00, T_4 (Supriya) with 50.00, and T_2 TSC-Rama with 53.25. However, it took the maximum number of days (55.00) by T_3 (Hariyali) variety to be harvested. According to research, the amount of time needed for harvesting and reaching edible size varied between 48 and 59 days. Numerous environmental elements, including the availability of moisture, light, air, and the ideal temperature, affect seed germination. However, germination is also significantly influenced by the genotype of the plant. It is possible that these variances are due to genetic inheritance of traits like seed vigour and dormancy. According to Kerketta *et al.* (2023), perennial spinach cultivars require a minimum of 30 days to develop, which supports the findings of our study. Similar results for days to 50% germination in spinach were also reported, which validates the findings.

Fresh weight of leaf (g): The largest total fresh weight of the plant, measured by variety T_1 (All Green), was 50.57 g. However, variety T_4 (Supriya) had the lowest total fresh weight of the plant, weighing 33.49 g. The general growth in vegetative structure of various varieties, which is determined by the genetic composition of the varieties as well as their environmental conditions, may be the cause of these variations in fresh weight. The current results are consistent with the work of Joseph *et al.* (2023), who found that T_1 (All Green) types produced the maximum fresh weight (11.73g), which validates the current study's findings.

Dry weight of leaf (g): The data in fig.4.8 demonstrated that the dry weight of the leaves varied significantly. T_1 (All Green) recorded the highest dry weight of leaves (4.90 g) among all five varieties. However, T_3 had the lowest dry weight of leaves (4.07 g). Different sources of organics, nutrients, and their combination in the leaves were found to considerably vary the total dry weight content of radish root per plant. Agarwal *et al.* (2021) also observed a similar finding. According to reports, T_1 (All Green) cultivars produced the maximum dry weight (1.38g), which is consistent with the results of this investigation.

Yield per plant (g): Data regarding yield per plant was documented at harvest and is shown in fig. 4.9 The highest yield per plant (60.70 g) was reported by T_1 (All Green) among the five varieties followed by T_5 (Haldibari) with 59.35 g. T4 had the lowest yield, measuring 57.65 g. The results of Prasad *et al.* (2023)

are consistent with the current findings who found that the maximum yield per plant (0.64 g).

Yield plot $^{-1}$ (kg/m^2): The yield plot^{-1} (kg/m^2) data was collected during harvest and is shown in fig. 4.10 T_1 (All Green) had the highest yield plot^{-1} (2.56 kg) out of all five varieties followed by T_5 (Haldibari) with 2.13 kg. However, treatment T_4 (1.35 kg) had the lowest yield. This could be because there was less competition for sunlight and vital soil nutrients, which likely encouraged the leaves to accumulate photosynthesis. The current results are consistent with those of Methella *et al.* (2023) found that the Banarasi variety produced the highest yield (0.375 kg) per plot, while the Sathi variety produced the maximum yield (4.52 kg), supporting the current study that different varieties had distinct yields due to a number of factors.

Total yield (kg ha^{-1}): The T_1 (All Green) variety produced the highest yield at 20.38 kg ha^{-1}, followed by T_5 (Haldibari) with 18.62 kgha^{-1}, while treatment T_4 (Supriya) recorded the lowest yield at 13.54 kgha^{-1}. According to Methela *et al.* (2020), the Sathi variety produced the highest yield, reaching 22.28 kgha^{-1}. Yield variations among treatments can be attributed to factors such as genetic variability, leaf weight, plant height, and leaf length. The authors also emphasized the critical role of genetic variability, heritability of superior traits, and genetic advancement in determining overall spinach yield, suggesting that increased leaf weight, plant height, and leaf length are key contributors to higher productivity.

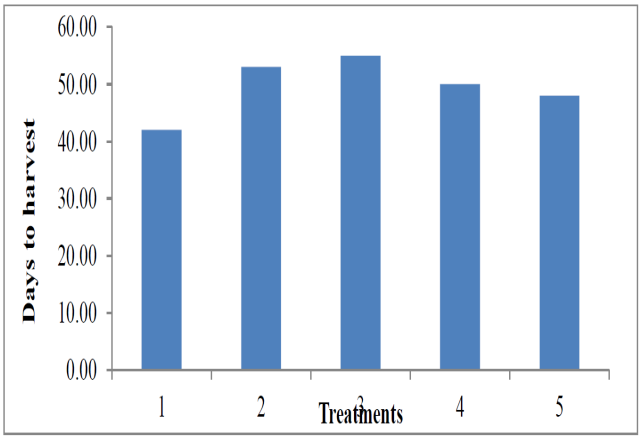

Fig. 6: Performance of different varieties of Spinach on days to harvest

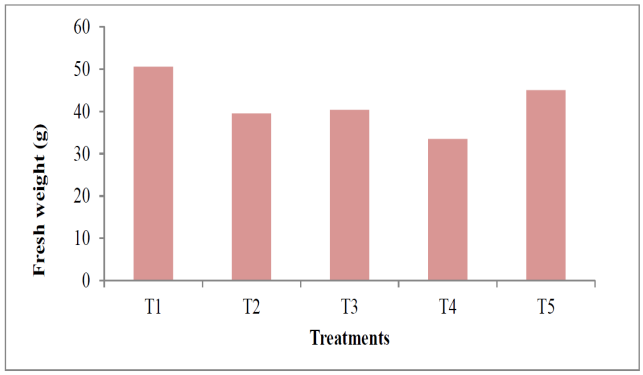

Fig. 7: Performance of different varieties of Spinach on fresh weight (g)

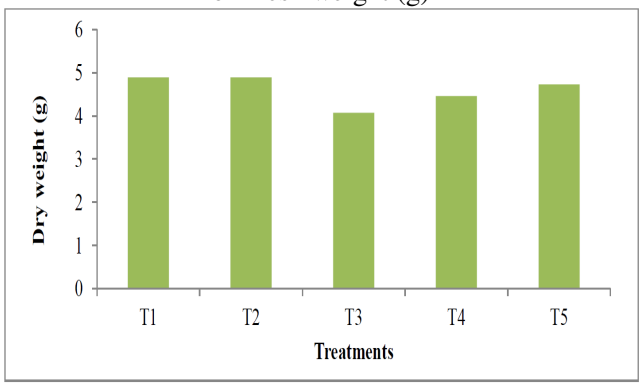

Fig. 8: Performance of different varieties of Spinach on dry weight (g)

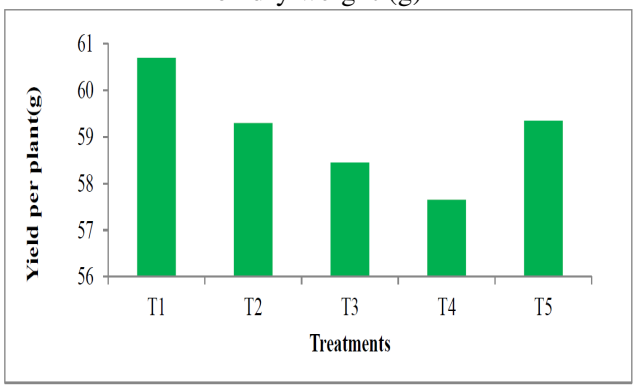

Fig. 9: Performance of different varieties of Spinach on yield per plot (g)

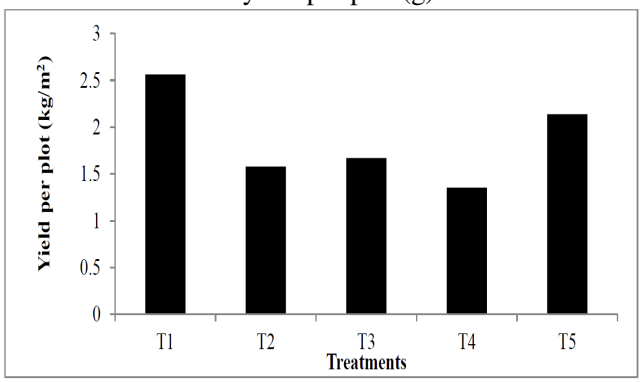

Fig. 10: Performance of different varieties of Spinach on yield per plot (kg)

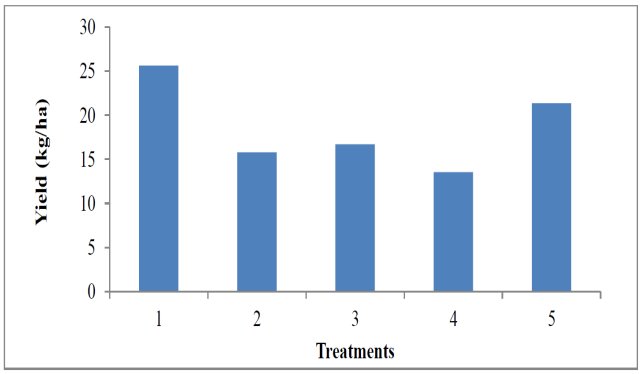

Fig. 11 : Performance of different varieties of Spinach on yield (kg /ha)

Quality attributes

Moisture content (%): Table 4.1.3 presents the analytical results for the leaves' moisture content. A comparison of the data showed that there were considerable differences in the leaves' moisture content between the various treatments. Variety T_1 had the highest moisture content (90.32%), whereas variety T_4 had the lowest (86.58%). The high water content in spinach's cells and tissues is the main cause of its high moisture content. Temperature, relative humidity during growth and harvest, rainfall, and soil water potential can all have an impact on the variances in moisture content among the spinach cultivars. Shadap *et al.* (2023) found similar findings, stating that all green types provided the highest moisture content percentage (94.32%) further supporting the outcomes of the present study.

Total soluble solids (TSS) of leave (^{0} Brix): It is evident from the data presented in Table 4.3 that among the 5 treatments, the highest value of TSS (%) was recorded in T_1 (6.73). T_2 (TSC-Rama), T_3 (Hariyali) and T_4 (Supriya) which was statistically *at par*. The lowest TSS was recorded in T_2 (5.69). The current results are consistent with the work of Agarwal *et al.* (2021), found that (All Green) varieties produced the maximum TSS (6.89), which validates the current study's findings.

Titratable acidity (%): According to the information in Table 4.1.3, variation T_3 had the highest titratable acidity (0.73%), followed by variety T_4 (0.69%). Variety T_5 (0.69%) and variety T_3 (0.73%) were statistically comparable. Variety T_1 has the lowest titratable acidity (0.56%). Genetics, growing circumstances, post-harvest management, and fermentation processes are some of the elements that contribute to the variance in titratable acidity across the spinach cultivars. The results of the current study are supported by similar findings published by Alfredo *et al*. (1983), who stated that the Ozarka varieties yielded the maximum titratable acidity (1.5%).

Ascorbic acid content of leave (mg 100 g^{-1}): Each of the examined spinach varieties exhibited varying quantities of this essential nutrient, and this had a major impact on the ascorbic acid content in the leaves. In particular, variety T_1 (All Green) had the greatest ascorbic acid content in the leaves; with 26.29 mg per 100 g. Variety T_4 came in second, with 26.13 mg per 100 g. However, variety T_2, also called TSC-Rama, had the lowest ascorbic acid content in the leaves, measuring just 25.41 mg per 100 g. This indicates that the variety has a poorer nutritional value overall. It's interesting to note that these results align with those of Agarwal *et al.* (2021), who found that all green varieties produced the most ascorbic acid (26.05 mg/100g). Their study also found that ascorbic acid levels varied amongst spinach varieties, which supports the findings of the current study. This supports the notion that the ascorbic acid content of different spinach varieties is influenced by their genetic characteristics and growing conditions, which is significant for consumers looking to reap the health advantages of this vital vitamin.

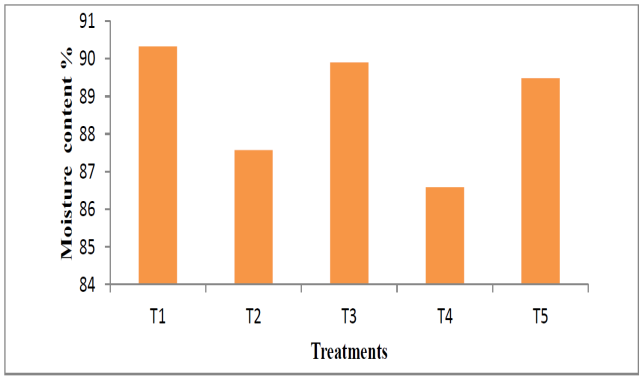

Fig. 12: Performance of different varieties of Spinach on Moisture content %

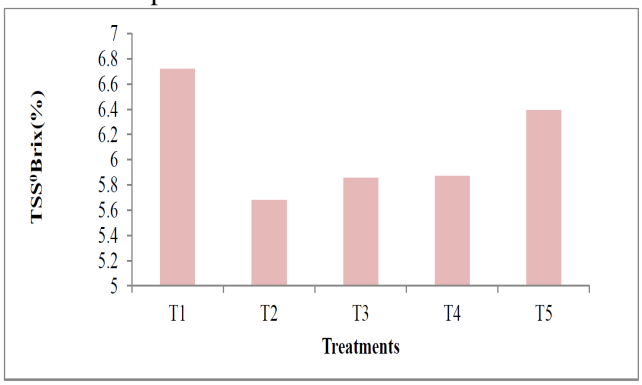

Fig. 13: Performance of different varieties of Spinach on TSS^{0}Brix in treatments of Spinach

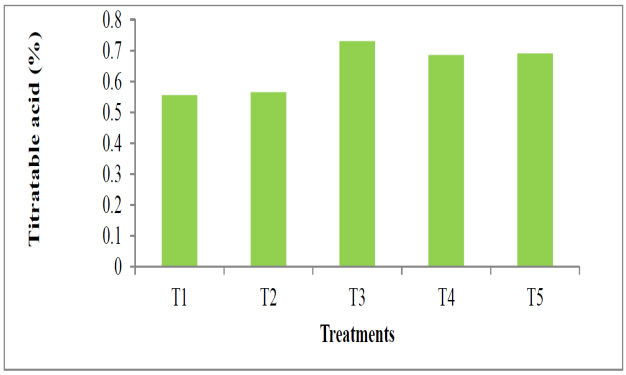

Fig. 14: Performance of different varieties of Spinach on Titratable acidity (%)

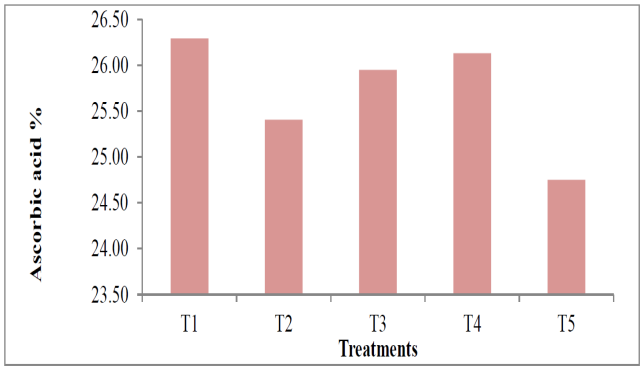

Fig. 15: Performance of different varieties of Spinach on Ascorbic acid %

Conclusion

In this experiment, the T_1 (All Green) variety outperformed others in growth and yield, with a plant height of 23.67 cm, leaf length of 15.38 cm, leaf width of 9.1 cm, 19.90 number of leaves, and a leaf area of 154.53 cm², yield per plot average of 2.56 kg and yield kg /ha an average of 25.63 t/h. T_1 also had the highest moisture content at 90.32% and TSS at 6.73° Brix. While ascorbic acid was highest in T_4 (26.81 mg/100g) and titratable acidity was highest in T_3 (0.73%).The results suggest that T_1 (All Green) offers the best yield and benefits under Namsai conditions.

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