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SHORT COMMUNICATION

# Optimizing sowing time and leaf cuttings for seed yield and quality of palak (*Beta vulgaris* var. *bengalensis* L.)

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Palak or spinach beet (*Beta vulgaris* var. *bangalensis* L.) is a widely grown leafy vegetable in India. It is most likely an inhabitant of the Indo-China region (Nath, 1976). Being a leafy vegetable, it is very rich in minerals, vitamins A and C, and contains significant amounts of protein, calcium, iron, and fiber, which makes it essential in the human diet (Narayan *et al*., 2018; Singh *et al*., 2021). Palak is an essential part of home gardens around the world; whereas the requirements for commercial production of fresh leaves and seeds are quite different. Non-availability of quality seeds is the main obstacle in cultivation. Several factors directly influence the yield and quality of palak seed. One major aspect influencing plant development and productivity is the time of sowing. It is influenced by external factors such as humidity, light intensity, temperature, and day length (Abed and Shebl, 2016). A suitable sowing date provides optimal conditions for the production of palak seeds. Mid-October sowing of the palak crop showed the highest vegetative growth and yield compared to November sowing (Ramadan, 2004; Sensoy et al., 2011; Singh and Singh, 2021).

The green leaf yield of palak (Spinach beet) depends on the vegetative growth, the number of leaves per plant, leaf size and height of the plant, etc. can express it. Crop cutting is important to achieve more vegetative growth. Due to cutting, lateral shoots of the crop are formed, which eventually raises yield by increasing the number of leaves on each plant (Bharad et al., 2013). Singh and Gill (1983) obtained the highest yield of palak seeds when the crop was mowed once. Phor and Mangal (1991) reported that single cutting taken 40 days after sowing resulted in superior quality and increased seed yield, whereas Lal et al. (1979) discovered that cuttings were beneficial for seed yield in palak. Standardizing the time of sowing and the frequency of harvesting is crucial because there hasn't been a thorough study conducted to address the obstacles to the production of high-quality seeds. This may assure spinach growers more revenue in terms of fresh leaf and seed yield. Therefore, due

to the lack of research on these characteristics, the current study is focused on determining the best sowing time and quantity of leaf cuttings for spinach in order to maximize seed yield and quality.

The experiment was conducted at the Vegetable Research Farm and Seed Technology Centre, Haryana Agricultural University, Hisar, during the winters of 2015-16, 2016-17 and 2017-18. The climate of Hisar is subtropical, with extremely hot summers and cold winters. The experiment was laid out in a factorial randomized block design replicated thrice with four sowing times (D1: 10$^{th}$ October, D2: 25$^{th}$ October, D3: 10$^{th}$ November, and D4:25$^{th}$ November) and three green leaf cuttings (C0: No cutting, C1: One cutting and C2: Two cutting) comprising a total of 12 treatment combinations. The plot size was maintained at 3.0 × 3.0 m. The collected data presented in the tables are average values of various parameters. The statistical method described by Panse and Sukhatme (1961) was followed for the differentiation and interpretation of experimental results. For this using OPSTAT statistical software (http://14.139.232.166/opstat/index.asp) developed by Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India. All tests of significance were completed at the 5% level of significance. A critical difference was calculated to test the significance of the difference between the means of the two treatments. Seeds of palak cv. HS 23 were sown at a distance of 45 cm between rows and 10 cm between plants. The first leaf cutting was done 30 days after sowing and the next cuttings were done 20 days after the first cutting. Other agricultural practices and plant protection practices were implemented as per the Haryana Agricultural University Package of Practice. Data were recorded for green leaf yield (q/ha), seed yield (q/ha), standard germination (%), 100 seed weight (g), vigor index I and economics of different treatments. Green leaf yield and seed yield (q/ha) were estimated from the whole plot of each treatment. For calculating the weight of seeds, 100 seeds were randomly selected from each plot and weighed on an electronic scale. Standard germination was tested in four replicates of 100 seeds in a germination apparatus at 25 ± 1 °C according to the ISTA seed test protocol (ISTA, 1999). The vigor index was calculated using the formula provided by Abdul-Baki and Anderson (1973).

The economics of the treatments was calculated by taking the current price of produce (green leaf Rs. 1000/q and seed Rs. 10000/q) as well as expenditure on input cost (fixed cost + treatment cost)into consideration, and the economics of each treatment was worked out. The estimated cost of seed was taken Rs. 100/kg. Net returns were counted with the following formula:

$$\text{Net return} = \text{Gross return} - \text{Cost of cultivation}$$

The benefit-cost ratio was also determined to ascertain the economic viability of different treatments using the following formula:

$$\text{B: C ratio} = \frac{\text{Net return}}{\text{Cost of cultivation}}$$

Since there was no significant difference between the results of 2015-16, 2016-17 and 2017-18 with respect to different parameters, year-wise and pooled analyses were done and discussed the pooled data. Sowing time had a significant effect on total green leaf yield though it was significantly maximum (17.51 q/ha) when the crop was sown on 25$^{th}$ October as compared to other dates of sowing (Table 1). Climatic conditions and, in particular, temperature during the growing period of the crop affect the rate of plant biological processes that impact crop growth and development. Cutting had a prominent and significant effect on the total green leaf yield. The maximum green leaf yield was obtained with two cuttings (28.88 q/ha). However, in no cutting treatment, no leaf was harvested. The results corroborate the findings of Singh et al. (2013), who found an increase in fresh foliage yield with an increase in the number of cuttings in palak. Moreover, Awan et al. (2016) reported that the second cutting showed maximum plant height, fresh biomass (kg/ha), and dry biomass. The combined effects of sowing time and cuttings also illustrated that sowing time and cutting frequency significantly impacted the green leaf yield and the maximum was recorded in the combinations of the 25$^{th}$ October sown crop with two cuttings (33.54 q/ha). Narayan et al. (2018) also obtained a higher green leaf yield of palak with more cuttings in October sown crops.

The crop sown on 25$^{th}$ October gave the highest seed yield which was significantly higher than that on other sowing dates. Similarly, Singh et al. (2013) and Narayan et al. (2018) discovered that seed yield in palak is significantly influenced by the sowing date. Seed yield was considerably and significantly reduced in the November sown crop. Irrespective of sowing time, maximum seed yield was obtained with one cutting that was significantly higher than no cutting and two cuttings (Table 1). The results also showed that seed yield is considerably reduced with the increase in cutting when it is more than one. These results confirm the finding of Narayan et al. (2018) in palak. When the leaf cuttings increase, the apical growth is arrested, leading to the production of more branches, but its contribution to the total seed production decreases with the frequency of cutting. The interaction effect between cutting and sowing time was highly significant on the overall seed yield. Maximum (20.04 q/ha) was obtained from the 25$^{th}$ October sown crop with one cutting at 30 days after sowing compared to other treatment combinations (Table 1). Similar results were previously reported by Singh et al. (2013) in palak.

**Table 1:** Effect of sowing dates and leaf cutting on green leaf and seed yield of palak

| *Treatments* | *Green leaf yield (q/ha)* | | | | *Seed yield (q/ha)* | | | |
|---|---|---|---|---|---|---|---|---|
| | *2015-16* | *2016-17* | *2017-18* | *Mean* | *2015-16* | *2016-17* | *2017-18* | *Mean* |
| Date of sowing | | | | | | | | |
| $D_1$: 10th October | 16.72 | 15.09 | 16.88 | 16.23 | 22.53 | 11.99 | 14.18 | 16.23 |
| $D_2$: 25th October | 17.57 | 16.67 | 18.28 | 17.51 | 23.11 | 13.53 | 15.69 | 17.44 |
| $D_3$:10thNovember | 15.70 | 12.97 | 14.52 | 14.40 | 17.97 | 9.96 | 11.36 | 13.10 |
| $D_4$:25th November | 14.27 | 10.40 | 10.89 | 11.85 | 16.52 | 7.68 | 8.75 | 10.98 |
| CD at 5% | 1.00 | 1.08 | 1.25 | 1.11 | 0.97 | 1.15 | 1.33 | 1.15 |
| Cutting levels | | | | | | | | |
| $C_0$: No cutting | 0.00 | 0.00 | 0.00 | 0.00 | 19.85 | 11.37 | 12.97 | 14.73 |
| $C_1$: One cutting | 16.36 | 15.33 | 16.65 | 16.11 | 21.38 | 12.10 | 13.81 | 15.76 |
| $C_2$: Two cuttings | 31.83 | 26.02 | 28.79 | 28.88 | 18.88 | 8.91 | 10.71 | 12.83 |
| CD at 5% | 0.86 | 0.97 | 1.12 | 0.98 | 0.84 | 0.69 | 0.77 | 0.77 |
| Interactions (Sowing × Cutting) | | | | | | | | |
| $D_1 \times C_0$ | 0.00 | 0.00 | 0.00 | 0.00 | 20.41 | 12.00 | 14.46 | 15.62 |
| $D_1 \times C_1$ | 16.13 | 17.78 | 19.40 | 17.77 | 24.09 | 13.85 | 15.75 | 17.90 |
| $D_1 \times C_2$ | 34.02 | 27.50 | 31.25 | 30.92 | 23.09 | 10.12 | 12.34 | 15.18 |
| $D_2 \times C_0$ | 0.00 | 0.00 | 0.00 | 0.00 | 21.16 | 13.35 | 15.72 | 16.74 |
| $D_2 \times C_1$ | 17.36 | 18.75 | 20.84 | 18.98 | 26.11 | 15.90 | 18.12 | 20.04 |
| $D_2 \times C_2$ | 35.36 | 31.25 | 34.00 | 33.54 | 22.04 | 11.35 | 13.24 | 15.54 |
| $D_3 \times C_0$ | 0.00 | 0.00 | 0.00 | 0.00 | 19.27 | 11.02 | 12.15 | 14.15 |
| $D_3 \times C_1$ | 16.81 | 13.90 | 15.12 | 15.28 | 18.22 | 10.08 | 11.92 | 13.41 |
| $D_3 \times C_2$ | 30.28 | 25.00 | 28.44 | 27.91 | 16.44 | 8.78 | 10.02 | 11.75 |
| $D_4 \times C_0$ | 0.00 | 0.00 | 0.00 | 0.00 | 18.54 | 9.10 | 9.55 | 12.40 |
| $D_4 \times C_1$ | 15.16 | 10.88 | 11.23 | 12.42 | 17.10 | 8.55 | 9.45 | 11.70 |
| $D_4 \times C_2$ | 27.66 | 20.31 | 21.45 | 23.14 | 13.93 | 5.40 | 7.25 | 8.86 |
| CD at 5% | 1.72 | 1.68 | 2.12 | 1.84 | 1.68 | 1.90 | 2.08 | 1.89 |

The 100 seed weight was at par on 10th October and 25th October but significantly higher than the November sown crop (Table 2). Uncut (control) plants and one cutting gave the highest 100 seed weight (1.38 g), which was statistically higher than two cuttings (1.34 g). The decrease in seed yield can be associated with a decrease in plant height and leaf width, resulting in a decrease in photosynthate translocation responsible for seed development. However, the interaction effect between cuttings and sowing time was non-significant for 100 seed weight. The present findings in this study were in conformity with the results given by Sarkar et al. (2014). Standard germination (%) and vigor Index-1 were significantly higher when the crop was sown in October over November month (Table 3). This may be due to favorable climatic conditions during the month of October for proper growth and development of the plant, ultimately increasing seed quality. Cutting frequency exhibited beneficial effects on seed quality components. Standard germination and vigor Index-1 were found to be statistically maximum with one cutting (76.08%, 1044.50) compared to other levels of cuttings, respectively. The present results are in accordance with the results of Phor and Mangal (1991) who obtained the highest standard germination with one cutting in palak. Narayan et al. (2018) reported that cutting green leaves had a significant effect on seed germination and vigor in palak. However, repeated cuttings may adversely affect seed quality because less time is available for the absorption and storage of photosynthesis during the reproductive phase. It was found that two cuttings showed the lowest germination (74.15%) and vigor index-1 (1000.67) than single or no cutting.

The interaction of sowing time and the number of cuttings had a substantial impact on seed quality parameters like germination and vigor indices (Table 3). Palak, when cut

**Table 2:** Effect of sowing dates and leaf cutting on test weight of palak

| *Treatments* | *100 seed weight (g)* | | | |
|---|---|---|---|---|
| | *2015-16* | *2016-17* | *2017-18* | *Mean* |
| Date of sowing | | | | |
| $D_1$: 10th October | 1.42 | 1.40 | 1.41 | 1.41 |
| $D_2$: 25th October | 1.39 | 1.38 | 1.40 | 1.39 |
| $D_3$: 10thNovember | 1.36 | 1.34 | 1.34 | 1.35 |
| $D_4$: 25th November | 1.33 | 1.31 | 1.32 | 1.32 |
| CD at 5% | 0.02 | 0.02 | 0.04 | 0.03 |
| Cutting levels | | | | |
| $C_0$: No cutting | 1.39 | 1.37 | 1.37 | 1.38 |
| $C_1$: One cutting | 1.39 | 1.36 | 1.38 | 1.38 |
| $C_2$: Two cuttings | 1.34 | 1.34 | 1.35 | 1.34 |
| CD at 5% | 0.02 | 0.01 | 0.02 | 0.02 |
| Interactions (Sowing x Cutting) | | | | |
| $D_1 \times C_0$ | 1.42 | 1.40 | 1.41 | 1.41 |
| $D_1 \times C_1$ | 1.43 | 1.41 | 1.42 | 1.42 |
| $D_1 \times C_2$ | 1.40 | 1.38 | 1.39 | 1.39 |
| $D_2 \times C_0$ | 1.41 | 1.40 | 1.41 | 1.41 |
| $D_2 \times C_1$ | 1.41 | 1.40 | 1.41 | 1.41 |
| $D_2 \times C_2$ | 1.34 | 1.35 | 1.37 | 1.35 |
| $D_3 \times C_0$ | 1.38 | 1.35 | 1.35 | 1.36 |
| $D_3 \times C_1$ | 1.37 | 1.34 | 1.35 | 1.35 |
| $D_3 \times C_2$ | 1.32 | 1.32 | 1.33 | 1.32 |
| $D_4 \times C_0$ | 1.36 | 1.33 | 1.32 | 1.34 |
| $D_4 \times C_1$ | 1.34 | 1.31 | 1.32 | 1.32 |
| $D_4 \times C_2$ | 1.30 | 1.30 | 1.31 | 1.30 |
| CD at 5% | NS | NS | NS | NS |

**Table 3:** Effect of sowing dates and leaf cutting on standard germination (%) and vigor index-1 of palak

| *Treatments* | *Standard germination (%)* | | | | *Vigor index-1* | | | |
|---|---|---|---|---|---|---|---|---|
| | *2015-16* | *2016-17* | *2017-18* | *Mean* | *2015-16* | *2016-17* | *2017-18* | *Mean* |
| Date of sowing | | | | | | | | |
| $D_1$: 10th October | 78.47 | 75.53 | 76.29 | 76.76 | 1114.0 | 1025.6 | 1035.79 | 1058.46 |
| $D_2$: 25th October | 77.32 | 76.19 | 76.65 | 76.72 | 1106.0 | 1029.5 | 1043.42 | 1059.64 |
| $D_3$: 10thNovember | 74.91 | 73.33 | 73.99 | 74.08 | 1075.7 | 980.6 | 989.21 | 1015.17 |
| $D_4$: 25th November | 73.92 | 72.49 | 73.03 | 73.15 | 1012.8 | 919.6 | 925.02 | 952.47 |
| CD at 5% | 0.66 | 1.23 | 1.75 | 1.21 | 23.8 | 21.8 | 24.55 | 23.38 |
| Cutting levels | | | | | | | | |
| $C_0$: No cutting | 75.59 | 74.55 | 75.17 | 75.10 | 1049.1 | 995.4 | 1002.19 | 1015.56 |
| $C_1$: One cutting | 76.92 | 75.35 | 75.97 | 76.08 | 1097.7 | 1012.6 | 1023.19 | 1044.50 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $C_2$: Two cuttings | 75.36 | 73.26 | 73.83 | 74.15 | 1073.8 | 958.5 | 969.71 | 1000.67 |
| CD at 5% | 0.57 | 0.88 | 1.06 | 0.84 | 20.6 | 19.1 | 22.78 | 20.83 |
| Interactions (Sowing x Cutting) | | | | | | | | |
| $D_1 \times C_0$ | 77.14 | 75.60 | 76.42 | 76.39 | 1089.9 | 1026.6 | 1036.25 | 1050.92 |
| $D_1 \times C_1$ | 77.46 | 75.65 | 76.45 | 76.52 | 1119.5 | 1040.2 | 1051.12 | 1070.27 |
| $D_1 \times C_2$ | 78.47 | 75.35 | 76.00 | 76.61 | 1132.6 | 1009.9 | 1020.00 | 1054.17 |
| $D_2 \times C_0$ | 75.67 | 75.39 | 76.25 | 75.77 | 1061.9 | 1022.8 | 1041.75 | 1042.15 |
| $D_2 \times C_1$ | 79.92 | 78.87 | 78.82 | 79.20 | 1143.2 | 1087.2 | 1098.12 | 1109.51 |
| $D_2 \times C_2$ | 76.36 | 73.80 | 74.88 | 75.01 | 1112.7 | 978.7 | 990.40 | 1027.27 |
| $D_3 \times C_0$ | 75.00 | 73.55 | 74.00 | 74.18 | 1026.6 | 980.7 | 994.56 | 1000.62 |
| $D_3 \times C_1$ | 76.13 | 74.05 | 74.85 | 75.01 | 1116.2 | 1020.8 | 1026.95 | 1054.65 |
| $D_3 \times C_2$ | 73.60 | 72.40 | 73.12 | 73.04 | 1050.8 | 935.2 | 946.12 | 977.37 |
| $D_4 \times C_0$ | 74.55 | 73.10 | 74.00 | 73.88 | 1018.0 | 933.0 | 936.20 | 962.40 |
| $D_4 \times C_1$ | 74.18 | 72.87 | 73.75 | 73.60 | 1011.9 | 915.7 | 916.56 | 948.05 |
| $D_4 \times C_2$ | 73.03 | 71.49 | 71.33 | 71.95 | 999.0 | 910.0 | 922.30 | 943.77 |
| CD at 5% | 1.14 | 2.12 | 2.22 | 1.83 | 40.2 | 36.9 | 39.45 | 38.85 |

**Table 4:** Economics of different treatment combinations in palak (Rs./ha)

| *Treatments* | *Variable cost* | *Fixed cost* | *Total cost of cultivation* | *Returns from green leaf yield* | *Returns from seed yield* | *Gross returns* | *Net returns* | *B.C. Ratio* |
|---|---|---|---|---|---|---|---|---|
| $D_1 \times C_0$ | 1000 | 52336 | 53336 | 0 | 144600 | 144600 | 91264 | 1.71 |
| $D_1 \times C_1$ | 11885 | 52336 | 64221 | 19400 | 157500 | 176900 | 112679 | 1.75 |
| $D_1 \times C_2$ | 18727 | 52336 | 71063 | 31250 | 123400 | 154650 | 83587 | 1.18 |
| $D_2 \times C_0$ | 1000 | 52336 | 53336 | 0 | 157200 | 157200 | 103864 | 1.95 |
| $D_2 \times C_1$ | 12818 | 52336 | 65154 | 20840 | 181200 | 202040 | 136886 | 2.10 |
| $D_2 \times C_2$ | 20282 | 52336 | 72618 | 34000 | 132400 | 166400 | 93782 | 1.29 |
| $D_3 \times C_0$ | 1000 | 52336 | 53336 | 0 | 121500 | 121500 | 68164 | 1.28 |
| $D_3 \times C_1$ | 9708 | 52336 | 62044 | 15120 | 119200 | 134320 | 72276 | 1.16 |
| $D_3 \times C_2$ | 17172 | 52336 | 69508 | 28440 | 100200 | 128640 | 59132 | 0.85 |
| $D_4 \times C_0$ | 1000 | 52336 | 53336 | 0 | 95500 | 95500 | 42164 | 0.79 |
| $D_4 \times C_1$ | 7220 | 52336 | 59556 | 11230 | 94500 | 105730 | 46174 | 0.78 |
| $D_4 \times C_2$ | 13129 | 52336 | 65465 | 21450 | 72500 | 93950 | 28485 | 0.44 |

once on 25th October, sown crop gave significantly higher standard germination (79.20) and vigor Index-1(1109.51) compared to other treatment combinations.

The economics of various treatment combinations with benefit-cost ratio were also worked out and presented in Table 4, revealing that the maximum net returns (Rs. 1336886/ha) were obtained from the 25th October sown crop with one cutting as compared to other treatment combinations, while the lowest net returns (Rs. 28485/ha) was recorded from 25th November with two cuttings. The data further revealed that the maximum benefit-cost ratio (2.10) was obtained from the treatment combination of the 25th October sown crop with one cutting. From the outcome of the study based on three years, it can be concluded that sowing time and cutting frequency have a significant effect on green leaf yield, seed yield and its quality components. Thus, to get a higher yield and better seed quality, the crop should be sown on 25th October and cut leaves once after 30 days.

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