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Standardization of Sowing Time and Leaf Cuttings for Seed Yield and Quality Component of Palak (*Beta vulgaris* var *bengalensis*)

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ABSTRACT: A field study to evaluate the effects of sowing time and leaf cutting on the yield and quality of palak seed was conducted at Vegetable Research Farm of Chaudhary Charan Singh Haryana Agricultural University, Hisar for a period of three years. The treatment comprises four dates of sowing and three levels of leaf cutting. The results revealed that the crop sown on 25thOctober with one cutting had maximum seed yield (20.04 q/ha), 100 seed weight (1.41 g), germination (79.20%)and seed vigour index-1, which was significantly higher than the 10th October and November sown crop. More cuttings though increased the total green leaf yield but the seed yield and quality in terms of germination, test weight and vigour Index-1 were considerably reduced due to less absorption and storage of photosynthates. Thus, the crop was sown on 25th October with one cutting after 30 days of sowing gives maximum seed yield and better quality seed with an additional green leaf yield (18.98 q/ha)of palak.

Keywords: Palak; Leaf cuttings; Germination; Seed vigour; Seed yield; Economics

Palak or Indian beet or Spinach beet (*Beta vulgaris* var *bangalensis*) is one of the most common leafy vegetable grown and consumed in India. Spinach beet is most probably a native of the Indo-Chinese region. Being a leafy vegetable, it is very rich in minerals and vitamin A and C and contains appreciable amounts of protein, calcium, iron and roughage, thus, making it essential in the human diet [7].

Palak is an integral part of home gardens across the world, the requirement of commercial fresh leaf and seed production is totally different. Non-availability of quality seeds is a major constraint in cultivation. Several factors have a direct influence on the yield and quality of palak seed. The sowing date is an important factor that affects plant growth and production. It is related to environmental conditions e.g., temperature, day length, light intensity and humidity [2]. The suitable sowing date provides the optimum environmental conditions for palak seed production. Sowing in mid-October exhibited the highest vegetative growth values and yield of palak plants compared to sowing in November [10 & 12].

The yield of Palak (Indian spinach) depends on vegetative growth it may be expressed in terms of the number of leaves per plant, the size of leaf and plant height, etc. For obtaining more vegetative growth, cutting of crop is important due to cutting of crop side shoots are arises which increases the number of leaves per plant and ultimately increases the yield [4]. [13] obtained the highest palak seed yield when the crop was cut once. Whereas, [9] stated that one cutting at 40 days after sowing gave better quality and higher seed yield and [6] found cuttings to be profitable for seed yield in palak. In the same manner, the effect of frequent cuttings has been studied for palak (*Beta vulgaris* L.).

Due to the absence of any comprehensive study to overcome the hindrance in quality seed production, there is an urgent need for the standardization of sowing time and cutting frequency. This can ensure extra profits for the growers both in terms of fresh leaves and seed yield in palak. Therefore, the research gap on these attributes leads to the present investigation to determine the optimum sowing time and number of leaf cuttings on the seed yield and quality in palak.

MATERIALS AND METHODS

Experimental site and climatic conditions

The experiment was conducted at the Vegetable Research Farm and Seed Technology Centre, Haryana

Agricultural University, Hisar, during the winter of 2015-16, 2016-17, and 2017-18. The climate of Hisar is subtropical with extreme hot during the summer and freezing temperatures during winter.

Treatments and experimental design

The experiment was laid out in a factorial randomized block design replicated thrice with four sowing times (D1: 10th October, D2: 25th October, D3: 10th November, and D4:25th 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 m × 3.0 m.

Statistical analysis

The pooled data presented in the Tables are the mean values of different parameters. The statistical method described by [8] was followed for the analysis of variance and interpretation of experimental results. For this using OPSTAT statistical software (http://14.139.232.166/opstat/index.asp)developed by Chaudhry Charan Singh Haryana Agricultural University, Hisar, Haryana, India. All the tests of significance were complete dat 5% level of significance. The critical difference was computed to test the significance of the difference between the means of the two treatments.

Crop raising and data recording

Seeds of palak cv. HS 23 were sown within a row spacing of 45 cm and a plant spacing of 10 cm. The first leaf cutting was done 30 days after sowing and subsequent cuttings were done 20 days after the first cutting. Other agronomic practices and plant protection measures were followed as per Haryana Agricultural University's package of practice. Data were recorded on green leaf yield (q/ha), seed yield (q/ha), germination (%),100 seed weight (g), vigour index-I and economics of different treatments. Green leaf yield (q/ha) and seed yield (q/ha) were estimated from the entire plot for each treatment. For 100 seed weight, 100 seeds were selected from each plot at random and weighed on an electronic balance. Germination was tested as per ISTA seed testing rules [5] in a quadruplicate of 100 seeds each at 25±1°C in a germinator. The vigour index was calculated using the formula given by Abdul-Baki and Anderson [1].

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:

Net return = Gross return – Cost of cultivation

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

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

RESULTS AND DISCUSSION

Since there were no significant differences between the results of the years 2015-16, 2016-17 and 2017–18 with respect to different parameters, year-wise, and pooled analyses were done and discussed the pooled data.

Green leaf yield

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 on25th October as compared to other dates of sowing (Table 1). Climatic conditions like 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, no leaf was harvested. The results corroborate the findings of Singh *et al.*[14] who found an increase in fresh foliage yield with an increase in the number of cuttings in palak. Moreover, [3] reported that the second cutting showed maximum plant height, fresh biomass (Kg/ha), and dried 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 25th October sown crop with two cuttings (33.54 q/ha). [7] obtained a higher green leaf yield of palak with more number of cuttings in October sown crops.

Seed yield

Crop sown on 25th of October gave the highest seed yield that was significantly higher than that on other sowing dates. Perversely, [14 & 7] discovered that seed

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 x 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

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 more than one. These results confirm the finding of [7] in palak. As the cuttings are increased, the apical growth is arrested which though resulted in the production of more productive branches, but its contribution toward overall seed yield decreases with the higher 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 25th October sown crop with one cutting at 30 days after sowing compared to other treatment combinations. Similar results were reported by Singh et al. (2013) in palak.

Test weight

The 100 seed weight was at par on 10thOctober and 25thOctober 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 reduction in seed weight with increasing levels of cuttings could be attributed to reduced plant height and leaf area, resulting in less availability and translocation of photosynthates 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.* [11].

Standard germination and Vigour

Standard germination (%)and vigour Index-1 were significantly higher when the crop was sown in October over November month (Table 3). This may be due to favourable 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 vigour Index-1 were found to be statistically maximum with one cutting (76.08%,

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	N.S.	NS	NS

1044.50) compared to other levels of cuttings, respectively. The present results are in accordance with the results of [9] who obtained the highest germination with one cutting in the palak. [7] in palak reported that green leaf cutting significantly affected seed germination and vigour. However, repeated cuttings can adversely affect the seed quality because less time is available for the absorption and storage of photosynthates in the reproductive phase. It was found that two cuttings exhibited the lowest germination (74.15%) and vigour Index-1(1000.67), than one or no cuttings.

The interaction of sowing time and the number of cuttings had a substantial impact on seed quality parameters like germination and vigour indices (Table 3). Palak when cut once on 25th October sown crop gave significantly higher standard germination (79.20) and vigour Index-1(1109.51) compared to other treatment combinations.

Economics

The economics of various treatment combinations with benefit: cost ratio also workout and presented in Table 4,reveals that the maximum net return (Rs. 1336886 per hectare) was obtained from 25th October sown crop with one cutting as compared to other treatment combinations,

Table 3. Effect of sowing dates and leaf cutting on standard germination (%)andvigourindex-1of Palak

Treatments	Standard germination(%)				Vigourindex-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	Return from green leaf yield	Return from seed yield	Gross return	Net return	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

while the lowest net return (Rs. 28485/ha) was recorded from25th November with two cuttings. The data further reveal that the maximum benefit-cost ratio (2.10) was obtained from the treatment combination of the 25th of October sown crop with one cutting.

CONCLUSION

From the outcome of the study based on three years, it can be concluded that sowing time and cutting frequency had significant effects on green leaf yield, seed yield and its quality components. Thus, to obtain higher seed yield and better quality, the crop should be sown on the 25th of October and cut once after 30 days.

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