International Journal of Agriculture and Plant Science
www.agriculturejournal.in
Online ISSN: 2664-7664
Received: 30-04-2026, Accepted: 31-05-2026, Published: 15-06-2026
Volume 8, Issue 2, 2026, Page No. 270-273

Selection indices for seed yield and its contributing traits in fennel (*Foeniculum vulgare* Mill.)

Antiya P M[1], Naghera Y V[2*], Mungra K S[3], Vavdiya P A[4], Sarmali A H[5], Khaniya J K[6]
[1] Department of Genetics and Plant Breeding, N. M. College of Agriculture, Navsari Agricultural University, Gujarat, India
[2] Associate Professor, Department of Biotechnology, Junagadh Agricultural University, Gujarat, India
[3] Assistant Research Scientist, Navsari Agricultural University, Gujarat, India
[4] Assistant Professor, Polytechnic in Agriculture, Navsari Agricultural University, Gujarat, India
[5] Department of Bioscience, Sardar Patel University, Gujarat, India
[6] Assistant Professor, Department of Biotechnology, Junagadh Agricultural University, Gujarat, India
Corresponding Author: Naghera Y V
DOI: https://doi.org/10.66856/ijaps.2026.8.2.8124

Abstract
The present study was undertaken to construct selection indices in thirty genotypes of fennel (*Foeniculum vulgare* Mill.). Using the discriminant function technique, sixty-three selection indices pertaining to seed yield per plant and its five components were created. Generally speaking, a selection index performs better the more characters it has. The highest genetic advance and relative efficiency of 23.77 g and 136.52 % were reported by the index based on six characters *viz.*, seed yield per plant, seed width, test weight, seed length, seeds per umbellate and umbellates per umbel followed by an index based on five characters *i.e.* seed yield per plant, test weight, seed length, seeds per umbellate and umbellates per umbel having genetic gain and relative efficiency of 23.57 g and 135.36 % respectively. Both these indices can be used for selecting high-yielding genotypes of fennel.

Keywords: Fennel, selection index, genetic improvement

Introduction
Environmental influences have a significant impact on seed yield, a quantitative attribute. Direct selection for seed yield is therefore often misleading. Additionally, seed yield is influenced by several yield-contributing traits. Thus, it is important to consider seed yield and the factors that influence it when selecting the selection criteria for yield improvement.
The primary aim of a plant breeding program is to enhance the population of a crop. The advancement of any breeding initiative is largely influenced by the genetic diversity present and the efficacy of the selection methods employed. Previous research has documented genetic diversity among genotypes (Cheema *et al.*, 2004) [3], the interrelationships among various plant characteristics (Arshad *et al.*, 2004) [1] and the selection criteria applicable to segregating populations (Sarwar *et al.*, 2004) [13]. Among the various selection methods utilized for population enhancement, selection indices are regarded as valuable tools for breeders, enabling the simultaneous selection of multiple traits (Smith, 1936) [14]. This approach assists breeders in identifying desirable genotypes or families within a crop species during population improvement efforts. The methodologies for developing a selection index that maximizes selection gains were demonstrated by Smith (1936) and Hazel (1943) [7, 14]. Selection indices offer critical insights into which traits should be combined (Banziger & Lafitte, 1997). Numerous other researchers have also employed selection indices as a successful criterion in their breeding programs across various crops (Vikram & Roy, 2003[15]; Xie *et al.*, 1998; Dolan *et al.*, 1996). Nonetheless, the factors that determine the effectiveness of a selection index may differ among individual plant breeders.
Selection indices allow for the simultaneous improvement of many characters and work similarly to an extra component that results from the combination of different characteristics from which selection responses are required (Santos *et al.*, 2007) [12]. In breeding programs that are based on index selections rather than selections for individual characters, selection indices are employed to choose superior genotypes. Due to the simultaneous gains for several significant agronomic and economic characteristics, this technique has shown to be quite effective.
The objective of this study was to develop the selection index for 30 fennel genotypes using information on the nature of relationships between important yield-contributing characters and seed yield per plant.

Materials and Methods
The present experiment was conducted involving thirty diverse genotypes of fennel during *Rabi* 2023-24 in a randomized block design with three replications at Research Farm, Department of Genetics and Plant Breeding, N. M. College of Agriculture, Navsari Agricultural University, Navsari. Each entry was sown in a single row with a spacing of 45 × 30 cm. Observations were recorded on five randomly selected plants for the seed yield per plant (X_1), seed width (X_2), test weight (X_3), seed length (X_4), seeds per umbellate (X_5) and umbellates per umbel (X_6). For constructing the selection indices, the characters with positive correlation coefficients with seed yield per plant were considered. The model given by Robinson *et al.* (1951) [11] was used to construct selection indices and the development of required discriminant function. Using six

characters, total sixty three selection indices were constructed. The formula proposed by Robinson *et al.* (1951) [11] was also used to determine the corresponding genetic advance through selection. Assuming 100% selection efficiency for seed yield per plant, the relative effectiveness of various discriminant functions in comparison to direct selection for seed production was evaluated and contrasted.

Results and Discussion

Selection indices for seed yield per plant and other characters were constructed and examined to identify their relative efficiency in the selection of superior genotypes. The results on selection indices, discriminant functions, expected genetic gain and relative efficiency are presented in Table 1. The results showed that the genetic advance and relative efficiency assessed for different indices were higher than straight selection. When selection was based on two or more characters the genetic advance and relative efficiency assessed for different indices increased considerably and selection efficiency was also found to be better. As the index of two characters was calculated, then the maximum efficiency in selection for seed yield per plant was exhibited by a discriminant function involving seed yield per plant and umbellates per umbel (GA = 19.60, RE = 112.55 %). In an index of three characters, maximum efficiency was shown by the combination involving the traits *viz.*, seed yield per plant, seeds per umbellate and umbellates per umbel (GA = 22.30, RE = 128.06 %) whereas, the maximum efficiency was exhibited by a discriminant function involving the four traits *viz.*, seed yield per plant, test weight, seeds per umbellate and umbellates per umbel (GA = 23.25, RE = 133.56 %). In the index of five characters *viz.*, seed yield per plant, test weight, seed length, seeds per umbellate and umbellates per umbel (GA = 23.57, RE = 135.36 %) showed maximum efficiency. The best selection index identified in case of six character combinations was exhibited by a discriminant function involving the traits *viz.*, seed yield per plant, seed width, test weight, seed length, seeds per umbellate and umbellates per umbel (23.77 and 136.52 %). Thus, an increase in character combinations resulted in an increase in both genetic gain and relative efficiency. According to Robinson *et al.* (1951) [11], the efficiency of selection indices gradually increased as each extra character was added to the index formula. Additionally, Hazel and Lush (1943) [8] claimed that as the number of characters under selection rose, the superiority of index-based selection increased as well and it was noted that seeds per umbellate and umbellates per umbel were part of the all the character combinations showing highest relative efficiency and genetic advance in each group or indices involving three, four, five and six character combinations followed by test weight. Therefore, due weightage should be given to these characters while formulating selection index of fennel. Kumari and Sharma (2015), Ghasemi *et al.* (2017) and Ghasemi *et al.* (2019) [5, 6, 9] also used umbellates per umbel, seeds per umbellates and seed yield per plant as component characters for construction of selection indices in various related crops like coriander and cumin. According to Pushpa *et al.* (2023) [10], selection based on characteristics such as the number of branches, effective capitula and 100-seed test weight is probably the best way to increase safflower seed yield. Due weight should be given to the important selection indices when making selection for the advancement of seed yield in fennel, as the current study also showed that the discriminant function method of making selections in plants appears to be more useful than straight selection for seed yield alone.

Table 1: Selection indices with genetic advance in yield and relative efficiency with the use of equal weight (W1) method

Sr. No.	Indices	Character Combinations	Expected Genetic Advance	Relative efficiency (%)
1	I_1	$I=0.898X_1$	17.41	100.00
2	I_2	$I=0.834X_2$	0.31	1.79
3	I_3	$I=0.944X_3$	2.64	15.15
4	I_4	$I=0.583X_4$	0.65	3.74
5	I_5	$I=0.307X_5$	2.43	13.98
6	I_6	$I=0.804X_6$	8.62	49.52
7	I_{12}	$I=0.864X_1+5.42X_2$	17.67	101.50
8	I_{13}	$I=0.872X_1+1.437X_3$	19.04	109.35
9	I_{14}	$I=0.896X_1+1.069X_4$	17.81	102.29
10	I_{15}	$I=0.935X_1+0.186X_5$	18.46	106.05
11	I_{16}	$I=0.896X_1+0.793X_6$	19.60	112.55
12	I_{23}	$I=0.86X_2+0.95X_3$	2.84	16.30
13	I_{24}	$I=1.557X_2+0.454X_4$	0.97	5.55
14	I_{25}	$I=0.722X_2+0.306X_5$	2.45	14.10
15	I_{26}	$I=-0.272X_2+0.802X_6$	8.61	49.44
16	I_{34}	$I=1.018X_3+0.565X_4$	3.17	18.20

Table 1: Contd…

Sr. No.	Indices	Character Combinations	Expected Genetic Advance	Relative efficiency (%)
17	I_{35}	$I=0.809X_3+0.302X_5$	3.19	18.30
18	I_{36}	$I=0.807X_3+0.795X_6$	8.33	47.83
19	I_{45}	$I=-0.024X_4+0.289X_5$	2.29	13.17
20	I_{46}	$I=0.349X_4+0.797X_6$	8.53	48.97
21	I_{56}	$I=0.091X_5+1.114X_6$	12.37	71.05
22	I_{123}	$I=0.858X_1+4.463X_2+1.234X_3$	19.27	110.70
23	I_{124}	$I=0.872X_1+6.532X_2+0.132X_4$	18.09	103.88
24	I_{125}	$I=0.908X_1+4.556X_2+0.185X_5$	18.69	107.35
25	I_{126}	$I=0.872X_1+4.139X_2+0.793X_6$	19.78	113.63

26	I_{134}	$I=0.874X_1+1.484X_3+0.677X_4$	19.48	111.86
27	I_{135}	$I=0.93X_1+1.102X_3+0.189X_5$	19.91	114.33
28	I_{136}	$I=0.879X_1+1.294X_3+0.813X_6$	20.75	119.16
29	I_{145}	$I=0.956X_1+-0.014X_4+0.158X_5$	18.81	108.04
30	I_{146}	$I=0.899X_1+0.809X_4+0.79X_6$	19.89	114.24
31	I_{156}	$I=0.947X_1+-0.08X_5+1.171X_6$	22.30	128.06
32	I_{234}	$I=1.29X_2+1.006X_3+0.5X_4$	3.39	19.49

Table 1: Contd…

Sr. No.	Indices	Character Combinations	Expected Genetic Advance	Relative efficiency (%)
33	I_{235}	$I=1.29X_2+1.006X_3+0.5X_4$	3.39	19.49
34	I_{236}	$I=1.442X_2+0.774X_3+0.297X_5$	3.36	19.28
35	I_{245}	$I=0.058X_2+0.872X_3+0.798X_6$	8.36	48.04
36	I_{246}	$I=3.021X_2+-0.449X_4+0.272X_5$	2.48	14.25
37	I_{256}	$I=0.51X_2+0.419X_4+0.797X_6$	8.52	48.95
38	I_{345}	$I=-0.085X_2+0.094X_5+1.111X_6$	12.36	70.97
39	I_{346}	$I=0.977X_3+0.001X_4+0.288X_5$	3.45	19.79
40	I_{356}	$I=0.9X_3+0.455X_4+0.795X_6$	8.38	48.10
41	I_{456}	$I=0.903X_3+0.09X_5+1.112X_6$	12.04	69.17
42	I_{1234}	$I=0.863X_1+5.468X_2+1.311X_3+0.051X_4$	19.73	113.30
43	I_{1235}	$I=0.917X_1+4.667X_2+0.88X_3+0.176X_5$	20.14	115.65
44	I_{1236}	$I=0.871X_1+3.488X_2+1.135X_3+0.803X_6$	20.94	120.24
45	I_{1245}	$I=0.93X_1+7.711X_2+-1.2X_4+0.124X_5$	19.11	109.75
46	I_{1246}	$I=0.881X_1+5.363X_2+0.056X_4+0.783X_6$	20.10	115.44
47	I_{1256}	$I=0.929X_1+3.385X_2+-0.082X_5+1.172X_6$	22.45	128.96
48	I_{1345}	$I=0.945X_1+1.26X_3+-0.221X_4+0.163X_5$	20.30	116.61

Table 1: Contd…

Sr. No.	Indices	Character Combinations	Expected Genetic Advance	Relative efficiency (%)
49	I_{1346}	$I=0.883X_1+1.358X_3+0.539X_4+0.812X_6$	21.09	121.15
50	I_{1356}	$I=0.933X_1+1.241X_3+-0.084X_5+1.19X_6$	23.25	133.56
51	I_{1456}	$I=0.975X_1+-0.316X_4+-0.118X_5+1.173X_6$	22.54	129.48
52	I_{2345}	$I=3.146X_2+0.881X_3+-0.346X_4+0.27X_5$	3.71	21.30
53	I_{2346}	$I=0.493X_2+0.925X_3+0.503X_4+0.795X_6$	8.43	48.43
54	I_{2356}	$I=-0.188X_2+0.985X_3+0.09X_5+1.115X_6$	12.07	69.32
55	I_{2456}	$I=2.292X_2+-0.494X_4+0.059X_5+1.112X_6$	12.27	70.45
56	I_{3456}	$I=1.141X_3+-0.362X_4+0.06X_5+1.125X_6$	12.05	69.19
57	I_{12345}	$I=0.934X_1+7.408X_2+1X_3+-1.163X_4+0.122X_5$	20.58	118.23
58	I_{12346}	$I=0.876X_1+4.534X_2+1.205X_3+0.035X_4+0.798X_6$	21.30	122.32
59	I_{12356}	$I=0.928X_1+2.757X_2+1.127X_3+-0.087X_5+1.184X_6$	23.42	134.50
60	I_{12456}	$I=0.952X_1+6.756X_2+-1.339X_4+-0.152X_5+1.178X_6$	22.76	130.71
61	I_{13456}	$I=0.954X_1+1.471X_3+-0.685X_4+-0.132X_5+1.206X_6$	23.57	135.36
62	I_{23456}	$I=1.715X_2+1.108X_3+-0.495X_4+0.053X_5+1.123X_6$	12.09	69.42
63	I_{123456}	$I=0.946X_1+5.78X_2+1.269X_3+-1.39X_4+-0.158X_5+1.198X_6$	23.77	136.52

X1= Seed yield per plant, X2= Seed width, X3= Test weight, X4= Seed length, X5= Seeds per umbellate, X6= Umbellates per umbel

Conclusion

On the basis of correlation coefficient six characters *viz.*, seed yield per plant, seed width, test weight, seed length, seeds per umbellate and umbellates per umbel were selected for constructing selection index by use of equal weight method. According to the discriminant function analysis for selection indices, when selection was based on yield-contributing features rather than directly on seed yield per plant, the selection efficiency was greater than with straight selection. Adding two or more characters greatly improved the relative selection efficiency. The highest relative efficiency was obtained with six-character combinations *viz.*, seed yield per plant, seed width, test weight, seed length, seeds per umbellate and umbellates per umbel. It was noted that seeds per umbellate and umbellates per umbel were part of the most of all the character combinations showing highest efficiency and advance in each group or indices involving three, four, five- and six-character combinations.

Acknowledgement

The Department of Genetics and Plant Breeding, N. M. College of Agriculture, Navsari Agricultural University, Navsari, is acknowledged by the authors for providing the facilities and assistance required to carry out this experiment effectively.

References

1. Arshad M, Baksh A, Ghafoor A. Path coefficient analysis in chickpea (*Cicer arietium L.*) under field conditions. Pak. J. Bot.,2004:36(1):75-81.
2. Banziger M, Lafittee HR. Efficiency of secondary traits for improving maize for low nitrogen target environments. Crop Sci., 1977, 37, 1110-1117.
3. Cheema AA, Radhid M, Ashraf M, Qamar ZU. Genetic divergence in rice collections. Pak. J. Bot.,2004:36(3):557-565.
4. Dolan DJ, Stuthman DD, Kolb FL, Hewings AD. Multiple traits selection in a recurrent selection

population in oat (*Avena sativa L.*). Crop Sci.,2016:36(5):1207-1211.

5. Ghasemi F, Baghizadeh A, Mohammadinejad G, Kavoosi HR. Evaluation of selection indices for improving grain yield in *Cuminum cyminum L.* Iranian Journal of Medicinal and Aromatic Plants Research,2017:32(6):1088-1098.
6. Ghasemi F, Mohammadinejad G, Baghizadeh A, Kavossi HR. Improving the seed yield of cumin (*Cuminum cyminum L.*) genotypes using different selection indices under drought stress conditions. Iranian Journal of Medicinal and Aromatic Plants Research,2019:35(2):209-221.
7. Hazel LN. Genetic basis for constructing selection indices. Genetics, 1943, 28, 476-490.
8. Hazel LN, Lush JL. The efficiency of three methods of selection. The Journal of Heredity., 1943, 33, 393 399.
9. Kumari S, Sharma LK. Per Se performance and selection indices over irrigated and limited irrigation conditions in coriander (*Coriandrum sativum L.*). Journal of Pure and Applied Microbiology,2015:9(3):2571-2579.
10. Pushpa HD, Helan Baby Thomas, Anil Kumar A, Dudhe MY, Yadav P, Kamali A. Multivariate analysis of seed yield-related traits in safflower (*Carthamus tinctorius*) genotypes. Biological Forum – An International Journal,2023:15(10):1407-1412.
11. Robinson HF, Comstock RE, Harvey PH. Genotypic and phenotypic correlations in corn and their implications in selection. Agronomy Journal, 1951, 43, 282-287.
12. Santos FS, Amaral Júnior ATD, Freitas Júnior SDP, Rangel RM, Pereira MG. Genetic gain prediction by selection index in a UNB-2U popcorn population under recurrent selection. Bragantia,2007:66(3):389-396.
13. Sarwar G, Sadiq MS, Saleem M, Abbas G. Selection criteria in F3 population of mungbean (*Vigna radiata (L.) Wilczek*). Pak. J. Bot.,2004:36(2):297-310.
14. Smith HF. A discriminant function of plant selection. Ann. Eugenics, 1936, 7, 240-250.
15. Vikram A, Roy D. Selection of characters for constructing selection index in groundnut (*A. hypogea L.*). Legume Res.,2003:26(2):137-139.
16. Xie C, Xu S, Mosjidis JA. Multistage selection indices for maximum genetic gain and economic efficiency in red clover. Euphytica,2014:98(1-2):75-82.