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Normalized Cumulative Ranks for Maize Breeding and Varietal Recommender System

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Abstract- Nine varieties of maize (Zea mays L.) namely H4226, RAJAJI, TMMH826, TATA 849, KAVERI 25K-60, RMH 1818, KANAK, BISCO-940 and RASI 4640 were evaluated on thirteen parameters in a randomized block design with three replications. The objectives of the experiment were to select suitable plant types based on considering all the thirteen parameters, suggesting scope for further improvement and recommending suitable maize ideotypes for cultivation by farmers of this region. Normalized cumulative ranks analysis found BISCO-940, KAVERI 25K-60, H4226, TATA 849 and TMMH826 to be top five varieties that could be recommended to farmers for cultivation on the criteria of less number of leaves per plant, small and narrow leaves with high venation, early tasseling and silking, dwarf plant types with lower cob placement, long cobs with less number of bracts for ease of peeling off the cobs and thick cobs with more kernels and kernel rows.

Keywords: composites, hybrid maize, normalized cumulative ranks, synthetics and varietal recommender system.

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Normalized Cumulative Ranks for Maize Breeding and Varietal Recommender System

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Abstract- Nine varieties of maize (*Zea mays* L.) namely H4226, RAJAJI, TMMH826, TATA 849, KAVERI 25K-60, RMH 1818, KANAK, BISCO-940 and RASI 4640 were evaluated on thirteen parameters in a randomized block design with three replications. The objectives of the experiment were to select suitable plant types based on considering all the thirteen parameters, suggesting scope for further improvement and recommending suitable maize ideotypes for cultivation by farmers of this region. Normalized cumulative ranks analysis found BISCO-940, KAVERI 25K-60, H4226, TATA 849 and TMMH826 to be top five varieties that could be recommended to farmers for cultivation on the criteria of less number of leaves per plant, small and narrow leaves with high venation, early tasseling and silking, dwarf plant types with lower cob placement, long cobs with less number of bracts for ease of peeling off the cobs and thick cobs with more kernels and kernel rows. There is scope for further improvement in the top performer variety BISCO-940 in characters like cob length, & early tasseling and silking. All these three characters could be improved by crossing BISCO-940 with a single variety TMMH826. If this cross proves to be a heterotic combination then a hybrid maize variety could be thought or synthetics and composites could be developed from top five best performers. Thus, normalized cumulative ranks analysis is an excellent versatile tool for plant breeding and varietal recommender system.

Keywords: composites, hybrid maize, normalized cumulative ranks, synthetics and varietal recommender system.

I. Introduction

Maize (*Zea mays* L.) is grown globally in a wide range of environments. However, local field conditions of farmers might suit some specific varieties and farmers might try to look for such suitable varieties based on their criteria of selection. Donald 1968 gave the concept of crop ideotype and since then a lot of crop-ideotypes have been suggested. Here in this experiment, we examine nine maize varieties on thirteen characters *viz.*, leaves/plant, leaf length, leaf width, days to tasseling, days to silking, leaf venation, plant height, cob length, cob placement, number of bracts, number of kernel rows, kernels per row and cob diameter. The idea is to look for maize ideotype with less number of leaves per plant, small and narrow leaves with high venation index, early tasseling and silking, dwarf plant types with lower cob placement, long cobs with less number of bracts for ease of peeling off the bracts from cob and thick cobs with more kernels and kernel rows.

II. Materials and Methods

Nine maize varieties as listed in tables were evaluated on thirteen parameters as mentioned above in the introduction. The data were recorded on five randomly selected plants in each replication. The average values are given in table 1. These values were ranked to make them unitless so that the transformed data become additive. All the ranks of a variety were summed to get cumulative rank (CR) and CR values were divided by minimum value to get normalized cumulative ranks (NCR). These are given in table 2. On sorting table 2 on CR or NCR values in increasing order, we get table 3.

Table 4.1: Average values of three replications

Sort order (rows) VARIETY (down)	Leaves / plant	Leaf length (cm)	Leaf width (cm)	DAYS TO TASSELING	DAYS TO SILKING	LEAF V. INDEX	PLANT HEIGHT	EAR LENGTH	COB PLACEMENT	NO. OF BRACTS	No. of kernel rows	kernels /row	COB DIAMETER
	1	1	1	1	1	0	1	0	1	1	0	0	0
H4226	11	34.46	5.18	48	52	3.09	153.5	37.26	41.23	13	17	33	3.83
RAJAJI	13	47.03	5.8	50	53	2.58	127.1	41.17	53.55	11	14	31	3.85
TMMH826	13	43.09	4.16	47	51	3.6	107	42.64	44.6	12	15	27	3.75
TATA 849	12	34.92	4.66	52	54	2.79	116.4	38.41	44.45	12	15	33	3.84
KAVERI 25K-60	12	28.87	3.77	55	59	4.51	121.7	39.99	44.83	10	15	31	3.77
RMH 1818	11	35.06	5.03	52	55	2.78	108.3	37.91	48.42	10	13	32	4
KANAK	12	34.45	4.4	63	66	3.41	104.6	34.04	41.61	9	14	16	3.77
BISCO-940	12	28.9	3.82	63	66	3.66	94.91	34.03	32.9	11	15	33	3.95
RASI 4640	12	33.46	5.17	61	64	2.32	114.6	35.42	45.8	10	14	33	4.18

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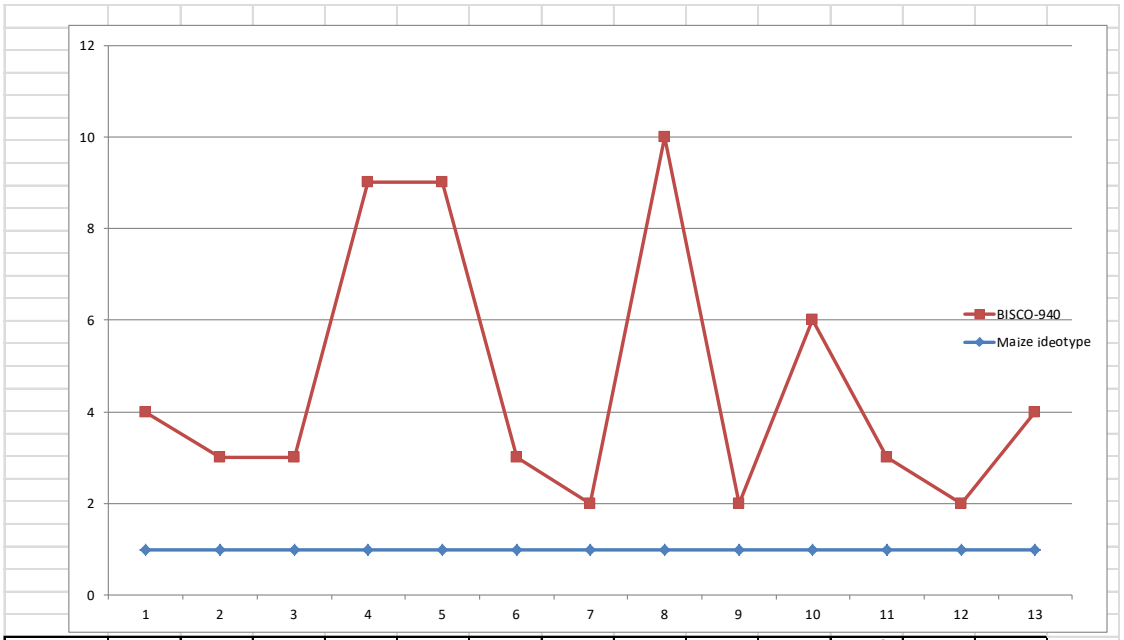
Sort order (rows) VARIETY (down)	Leaves / plant	Leaf length (cm)	Leaf width (cm)	DAYS TO TASSELING	DAYS TO SILKING	LEAF V. INDEX	PLANT HEIGHT	EAR LENGTH	COB PLACEMENT	NO. OF BRACTS	No. of kernel rows	kernels /row	COB DIAMETER	CR	NCR
	1	1	1	1	1	0	1	0	1	1	0	0	0		
H4226	1	5	8	2	2	5	9	6	2	9	1	1	6	57	1.21
RAJAJI	8	9	9	3	3	8	8	2	9	5	6	6	4	80	1.7
TMMH826	8	8	3	1	1	3	3	1	5	7	2	8	9	59	1.26
TATA 849	3	6	5	4	4	6	6	4	4	7	2	1	5	57	1.21
KAVERI 25K-60	3	1	1	6	6	1	7	3	6	2	2	6	7	51	1.09
RMH 1818	1	7	6	4	5	7	4	5	8	2	9	5	2	65	1.38
KANAK	3	4	4	8	8	4	2	8	3	1	6	9	7	67	1.43
BISCO-940	3	2	2	8	8	2	1	9	1	5	2	1	3	47	1
RASI 4640	3	3	7	7	7	9	5	7	7	2	6	1	1	65	1.38

Table 4.2: Ranks, cumulative ranks and the normalized cumulative ranks

III. Results and Discussion

Table 3 shows the preference order of varieties that should be considered by farmers for selecting suitable maize ideotype for cultivation in their fields in this region. Thus top five varieties namely BISCO-940, KAVERI 25K-60, H4226, TATA 849 and TMMH826 could be recommended for trials. As per table 3, the most suitable variety BISCO-940 could be improved further by paying attention to characters like cob length (ranking 9th) and days to tasseling and days to silking (both ranking 8th) by crossing it with TMMH826 (ranking 1st in all these three characters). The equal values of CR (and hence NCR) of H4226 and TATA 849 indicate that although both these varieties are equally good, yet they may differ in their ranks of various characters like plant height and number of bracts. If, by chance, the cross between BISCO-940 and TMMH826 proves to be heterotic, then a hybrid between these may be thought of and tried. Otherwise synthetic and composite varieties could be tried involving top few varieties. Thus, this analysis opens up a lot of potentials in maize breeding and recommending suitable maize ideotypes. Inbreds could also be analyzed like this to make single cross hybrids or try other potentials. This analysis has been used in many other crops also (Singh 2017, 2018; Singh and Kant 2022, Singh et al. 2018; Singh and Tiwari 2020 and Yadav et al. 2020). The top performer maize variety of this experiment BISCO-940 is also compared graphically as shown in Figure 1 with the maize ideotype being imagined. This graph shows scope for further improvement in most of the characters of the top performer maize variety BISCO-940 except plant height, cob placement and kernel rows. This means that BISCO-940 is at par with maize ideotype in these three characters only. Rest of the characters need maize breeders' attention to improve this variety further.



Characters	Leaves/ plant	Leaf length (cm)	Leaf width (cm)	DAYS TO TASSELING	DAYS TO SILKING	LEAF V. INDEX	PLANT HEIGHT	Cob LENGTH	COB PLACEMENT	NO. OF BRACTS	No. of kernel rows	kernels /row	COB DIAMETER
Maize ideotype	1	1	1	1	1	1	1	1	1	1	1	1	1
BISCO-940	3	2	2	8	8	2	1	9	1	5	2	1	3

Figure 1: BISCO-940 compared graphically with the maize ideotype being imagined here

Sort order (rows) VARIETY (down)	Leaves / plant	Leaf length (cm)	Leaf width (cm)	DAYS TO TASSELING	DAYS TO SILKING	LEAF V. INDEX	PLANT HEIGHT	EAR LENGTH	COB PLACEMENT	NO. OF BRACTS	No. of kernel rows	kernels /row	COB DIAMETER	CR	NCR
	1	1	1	1	1	0	1	0	1	1	0	0	0		
BISCO-940	3	2	2	8	8	2	1	9	1	5	2	1	3	47	1
KAVERI 25K-60	3	1	1	6	6	1	7	3	6	2	2	6	7	51	1.09
H4226	1	5	8	2	2	5	9	6	2	9	1	1	6	57	1.21
TATA 849	3	6	5	4	4	6	6	4	4	7	2	1	5	57	1.21
TMMH826	8	8	3	1	1	3	3	1	5	7	2	8	9	59	1.26
RMH 1818	1	7	6	4	5	7	4	5	8	2	9	5	2	65	1.38
RASI 4640	3	3	7	7	7	9	5	7	7	2	6	1	1	65	1.38
KANAK	3	4	4	8	8	4	2	8	3	1	6	9	7	67	1.43
RAJAJI	8	9	9	3	3	8	8	2	9	5	6	6	4	80	1.7

Table 4.3: Same as table 2 but after sorting on CR or NCR values in increasing order

IV. Summary and Conclusions

On critical examination of tables 1, 2 and 3, it could be safely concluded that top few (say five) varieties namely BISCO-940, KAVERI 25K-60, H4226, TATA 849 and TMMH826 could be recommended to farmer of this region for trials. On the other hand, maize breeders may try hybrid, synthetic and/or composite varieties involving these varieties in various combinations. This analysis could also involve screening inbreds, mutants and all kinds of variants for maize breeding.

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