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Restricted selection in foxtail millet *Setaria italica* (L.) Beauv.] For yield and nutritional components

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Abstract

Restricted selection was used for estimating the genetic advance of yield and nutritional components viz., days to 50% flowering, plant height, panicle length, productive tillers per plant, days to maturity, test weight, protein, carbohydrate, calcium, iron, zinc, copper, manganese, phosphorus and grain yield per plant. The genetic advance of all the fifteen characters under study was estimated by assigning equal economic weights to all characters as well as by using inverse of means as their economic weights. In both cases, the trait plant height recorded maximum estimate of genetic advance in 11 out of 15 cases. The main outcome of the present study is the occurrence of similar trend in the both cases i.e., by assigning equal economic weights and using inverse of means of respective characters as economic weights. This indicates that both ways of assigning weights were equal effective and will result in similar conclusions.

Keywords: Restricted selection, genetic advance, foxtail millet

Introduction

Foxtail millet is a self-pollinating crop with estimated rates of out crossing up to 1.4% (Li *et al.*, 1935) ^[6] with chromosome number $2n=18$, classified under family Poaceae and subfamily Panicoideae. The naming of this taxon evolved as the millet having panicles resembling a foxtail in appearance i.e., long panicle with soft long and erect hairs. The foxtail millet is believed to have first domesticated in Central China. Taxonomically, foxtail millet comprised two sub species: *Setaria italica* sub sp. *italica* and subsp. *viridis*. The sub species *viridis* is considered as the progenitor of the cultivated form. (Upadhyaya *et al.*, 2008) ^[14]. It is also called Italian millet, German millet, Chinese millet, Hungarian millet. In Andhra Pradesh, it is commonly called as 'Korra'. Its domestication and cultivation is estimated to have occurred over 4000 years ago (Chang, 1973 ^[1]; Ho, 1975 ^[3]). It has high nutritional value as it contains β -carotene, protein (12.3%), fat (4.7%), carbohydrate (60.6%) and ash (3.2%) besides minerals (Fe, Zn, K, Ca, Mg), antioxidants, dietary fiber, phytochemicals, vitamins (thiamine, riboflavin, niacin) and possesses low glycemic index (Rai, 2002) ^[8]. For improving the yield levels, different breeding programmes are available based on different kinds of selection techniques. Under certain situations the breeder might like to effect change in means of some characters while keeping the means of other characters unchanged. To enable this kind of selection, Kempthorne and Nordskog (1959) ^[5] introduced the concept of 'restricted selection indices' which enables us to restrict change in only some characters without affecting the development in other characters.

Materials and Methods

A total of sixty genotypes of foxtail millet for this study was laid out in a Augmented Randomised Complete Block Design (Federer, 1956) ^[2] with four checks viz., Suryanandi, Prasad, Co 7 and Krishnadevaraya in each block. The trial was carried out during *kharif*, 2018-19 at RARS, Lam, Guntur, Andhra Pradesh, which is located at 16.10° N latitude, 28.29° E longitude and 31.5 m altitude. Each genotype was grown in a two rows of 4 m length with a spacing of 22.5 cm between the rows and 10 cm between the plants. Data were collected on five randomly selected plants per treatment for plant height, panicle length, productive tillers per plant and grain yield per plant. However, data on days to 50% flowering, days to maturity, test weight, protein, carbohydrate, calcium, iron, zinc, copper, manganese and phosphorus

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were recorded on plot basis. Seed protein was estimated using Micro kjeldhal Distillation Method (Sadasivam and Manickam, 1996) ^[9]. Carbohydrate content was estimated using the procedure given by Sadasivam and Manickam (1997) ^[10]. Iron, Zinc, Copper and Manganese was estimated with the help of Atomic Absorption Spectrophotometer (AAS) as per Tandon (1999) ^[13]. Similarly, phosphorus content was also estimated as per procedure given by Tandon (1999) ^[13]. While calcium content was estimated using Versenate titration method (Jackson, 1967) ^[4]. Among the fifteen characters taken for present study, selection was restricted to only fourteen characters at a time without changing the mean of remaining fifteenth character. All such fifteen possible cases were worked out according to Singh and Chaudhary (2010) ^[11] and the genetic advances for the fourteen characters subjected to selection in each of the fifteen cases were estimated.

Results and Discussion

The estimates of genetic advances of all the fourteen characters subjected to selection in each of the fifteen cases, when equal economic weights were assigned are presented in the table 1.

In first case when selection was restricted to fourteen characters without affecting the mean of days to 50% flowering, highest estimate of genetic advance was recorded by plant height (11.940) followed by carbohydrate (4.642) and grain yield per plant (3.921) while the least estimate was observed for copper (-0.112).

In second case when selection was restricted to fourteen characters without affecting the mean of plant height, highest estimate of genetic advance was recorded by days to 50% flowering (6.696) followed by days to maturity (5.423) and carbohydrate (3.597) while the least estimate was observed for zinc (-0.111).

In the third case when selection was not applied on panicle length but on all other fourteen traits, highest estimate of genetic advance was recorded by days to 50% flowering (7.458) followed by days to maturity (6.334) and plant height (3.036) while the least value was recorded by copper (-0.091).

In the fourth case where productive tillers per plant was left out and selection was done for other fourteen traits, the highest estimate of genetic advance among the remaining fourteen characters was recorded by days to 50% flowering (5.221) followed by plant height (4.446) and days to maturity (4.368) while the least value was observed for copper (-0.071).

In the fifth case when selection was restricted to fourteen characters leaving days to maturity, the highest estimate of genetic advance was recorded by plant height (11.789) followed by carbohydrate (4.745) and panicle length (3.268) while the least value was recorded by days to 50% flowering (-0.384).

In the sixth case where test weight was not considered for selection, the highest estimate of genetic advance among the remaining fourteen characters was recorded by plant height (5.926) followed by days to 50% flowering (5.588) and days to maturity (4.696) and least value was observed for iron (-0.087).

In the seventh case when selection was restricted to fourteen characters without affecting the mean of protein, highest estimate of genetic advance was recorded by plant height (9.726) followed by carbohydrate (3.980) and days to 50% flowering (3.464) while least value was copper (-0.106).

In the eighth case when selection was imposed on the combination of fourteen characters which does not include carbohydrate, highest estimate of genetic advance was recorded by plant height (8.621) followed by days to 50% flowering (4.992) and days to maturity (4.493) and least value was observed for copper (-0.078).

In the ninth case when selection was restricted to the combination of fourteen characters which does not include calcium, highest estimate of genetic advance was recorded by plant height (9.682) followed by carbohydrate (3.916) and days to 50% flowering (3.581) and the least value was observed for copper (-0.102).

In the tenth case when selection was restricted to the combination of fourteen characters which does not include iron, highest estimate of genetic advance was observed for plant height (9.334) followed by carbohydrate (3.983) and days to 50% flowering (3.689) and the least value recorded by copper (-0.110).

In the eleventh case when selection was not applied on zinc, highest estimate of genetic advance was recorded by plant height (9.471) followed by carbohydrate (3.762) and days to 50% flowering (3.744) and least value was observed for copper (-0.101).

In the twelfth case where copper was left out and selection was done for other fourteen traits, highest estimate of genetic advance was recorded by plant height (9.178) followed by carbohydrate (3.758) and days to 50% flowering (3.706) and the least value was observed for iron (-0.056).

In the thirteenth case where manganese was not considered for selection, the highest estimate of genetic advance among the remaining fourteen characters was recorded by plant height (9.143) followed by carbohydrate (4.113) and grain yield per plant (3.671) and least value was recorded by copper (-0.096).

In the fourteenth case when selection was not applied on phosphorus, the highest estimate of genetic advance was recorded by plant height (9.310) followed by carbohydrate (3.988) and days to 50% flowering (3.699) and least value was observed for copper (-0.110).

In the fifteenth case when selection was restricted to the combination of fourteen characters which does not include grain yield per plant, highest estimate of genetic advance was recorded by days to 50% flowering (6.113) followed by days to maturity (5.399) and plant height (3.784) and least value was observed by zinc (-0.021).

Out of above fifteen cases of restricted selection, in eleven cases viz., case 1, case 5, case 6, case 7, case 8, case 9, case 10, case 11, case 12, case 13 and case 14, plant height recorded maximum estimates of genetic advance (Table 1).

Similarly the estimates of genetic advances of all the fourteen characters in each of the fifteen cases, when inverse of means were used as economic weights are presented in the table 2.

In first case when selection was restricted to fourteen characters without affecting the mean of days to 50% flowering, highest estimate of genetic advance was recorded in case of plant height (8.803) followed by grain yield per plant (3.738) and carbohydrate (3.721) while the least estimate was observed for days to maturity (-0.180).

In second case when selection was restricted to fourteen characters without affecting the mean of plant height, highest estimate of genetic advance was recorded by days to 50% flowering (3.739) followed by carbohydrate (2.932) and grain yield per plant (2.500) and least value was observed for copper (0.013).

In the third case when selection was not applied on panicle length, the highest estimate of genetic advance was recorded by days to 50% flowering (5.254) followed by days to maturity (3.539) and grain yield per plant (1.297) and least value was observed for carbohydrate (-0.077).

In the fourth case where productive tillers per plant was not subjected to selection the higher estimate of genetic advance among the remaining fourteen characters was recorded by days to 50% flowering (2.625) followed by plant height (2.196) and carbohydrate (1.513) while the least value was observed for phosphorus (0.036).

In the fifth case when selection was restricted to fourteen characters leaving days to maturity, the highest estimate of genetic advance was recorded by plant height (8.325) followed by grain yield per plant (3.678) and carbohydrate (3.640) while least value was observed for copper (-0.007).

In the sixth case where test weight was not considered for selection, the highest estimate of genetic advance among the remaining fourteen characters was recorded by plant height (3.528) followed by days to 50% flowering (3.221) and days to maturity (1.702) and least value was recorded by protein (0.005).

In the seventh case when selection was restricted to fourteen characters without affecting protein, highest estimate of genetic advance was recorded by plant height (7.950) followed by grain yield per plant (3.610) and carbohydrate (3.495) and least value observed for copper (-0.015).

In the eighth case when selection was imposed on the combination of fourteen characters which does not include carbohydrate, highest estimate of genetic advance was recorded by plant height (6.688) followed by days to 50% flowering (2.690) and grain yield per plant (2.590) and the least value was observed for phosphorus (0.024).

In the ninth case when selection was restricted to the combination of fourteen characters which does not include calcium, highest estimate of genetic advance was recorded by plant height (8.115) followed by grain yield per plant (3.675) and carbohydrate (3.429) and the least value was recorded by copper (-0.009).

In the tenth case when selection was restricted to the combination of fourteen characters excluding iron, highest estimate of genetic advance was observed for plant height

(8.739) followed by grain yield per plant (3.716) and carbohydrate (3.655) while the least value was recorded by copper (-0.003).

In the eleventh case when selection was excised on the combination of fourteen characters which does not include zinc, highest estimate of genetic advance was recorded by plant height (7.760) followed by carbohydrate (3.772) and grain yield per plant (3.701) and the least value was observed for copper (-0.027).

In the twelfth case when selection was imposed on the combination of fourteen characters which does not include copper, highest estimate of genetic advance was recorded by plant height (7.707) followed by grain yield per plant (3.560) and carbohydrate (3.448) and the least value was observed for phosphorus (0.019).

In the thirteenth case where manganese was not considered for selection, the highest estimate of genetic advance among the remaining fourteen characters was recorded by plant height (7.548) followed by grain yield per plant (3.878) and carbohydrate (3.698) and least was recorded by copper (0.005).

In the fourteenth case when selection was not applied on phosphorus, the highest estimate of genetic advance was recorded by plant height (7.505) followed by grain yield per plant (3.756) and carbohydrate (3.653) while least value was observed for copper (-0.021).

In the fifteenth case when selection was restricted to the combination of fourteen characters which does not include grain yield per plant, highest estimate of genetic advance was recorded by days to 50% flowering (3.559) followed by days to maturity (2.173) and plant height (1.029) while least value was observed for test weight (-0.005).

It was evident that plant height registered maximum estimates of genetic advance in the similar cases (*i.e.*, case 1, case 5, case 6, case 7, case 8, case 9, case 10, case 11, case 12, case 13 and case 14) when both equal economic weights (Table 1) and inverse of means (Table 2) are used as economic weights. This indicates that both the methods of employing economic weights are equally efficient. Similar equal efficiency of both ways of assigning economic weights was also reported by Srilakshmi and Babu (2016)^[12] in finger millet and Priya and Babu (2017)^[7] in rice.

Table 1: Genetic advance estimates (ΔG_i) in 15 cases of restricted selections for 60 genotypes of foxtail millet [*Setaria italica* (L.) Beauv.] When equal economic weights are assigned

| Case | Traits | Days to 50% flowering | Plant height | Panicle length | Prod. tillers per plant | Days to maturity | Test wt | Protein | Carbohydrate | Calcium | Iron | Zinc | Copper | Manganese | Phosphorus | Grain Yield/plant |
|------|-------------------------|-----------------------|--------------|----------------|-------------------------|------------------|---------|---------|--------------|---------|--------|--------|--------|-----------|------------|-------------------|
| 1 | Days to 50% flowering | 0.000 | 11.940 | 3.197 | 0.827 | 0.638 | 0.363 | -0.046 | 4.642 | 0.280 | -0.062 | -0.085 | -0.112 | 0.044 | 0.005 | 3.921 |
| 2 | Plant height | 6.696 | 0.000 | 1.121 | 0.483 | 5.423 | 0.236 | 0.793 | 3.597 | 0.878 | 0.164 | -0.111 | -0.099 | 0.063 | -0.008 | 2.228 |
| 3 | Panicle length | 7.458 | 3.036 | 0.000 | 0.311 | 6.334 | 0.101 | 0.449 | 0.724 | 0.453 | 0.017 | 0.045 | -0.091 | 0.103 | -0.006 | 1.218 |
| 4 | Prod. tillers per plant | 5.221 | 4.446 | 0.748 | 0.000 | 4.368 | 0.076 | 0.485 | 2.207 | 0.303 | 0.202 | 0.059 | -0.071 | 0.091 | 0.010 | 0.740 |
| 5 | Days to maturity | -0.384 | 11.789 | 3.268 | 0.815 | 0.000 | 0.360 | 0.004 | 4.745 | 0.244 | -0.016 | -0.065 | -0.093 | 0.045 | 0.008 | 3.982 |
| 6 | Test wt | 5.588 | 5.926 | 0.574 | 0.211 | 4.696 | 0.000 | 0.187 | 0.937 | 0.582 | -0.087 | 0.043 | -0.005 | 0.114 | -0.001 | 0.573 |
| 7 | Protein | 3.464 | 9.726 | 2.533 | 0.772 | 3.329 | 0.324 | 0.000 | 3.980 | 0.424 | 0.001 | -0.062 | -0.106 | 0.080 | 0.002 | 3.507 |
| 8 | Carbohydrate | 4.992 | 8.621 | 1.268 | 0.583 | 4.493 | 0.190 | 0.234 | 0.000 | 0.255 | -0.005 | 0.053 | -0.078 | 0.087 | 0.004 | 2.373 |
| 9 | Calcium | 3.581 | 9.682 | 2.507 | 0.758 | 3.361 | 0.328 | 0.256 | 3.916 | 0.000 | -0.001 | -0.051 | -0.102 | 0.060 | 0.002 | 3.569 |
| 10 | Iron | 3.689 | 9.334 | 2.502 | 0.763 | 3.455 | 0.325 | 0.235 | 3.983 | 0.404 | 0.000 | -0.067 | -0.110 | 0.073 | 0.002 | 3.518 |
| 11 | Zinc | 3.744 | 9.471 | 2.425 | 0.741 | 3.447 | 0.316 | 0.210 | 3.762 | 0.334 | 0.028 | 0.000 | -0.101 | 0.077 | 0.002 | 3.480 |
| 12 | Copper | 3.706 | 9.178 | 2.442 | 0.734 | 3.300 | 0.293 | 0.168 | 3.758 | 0.287 | -0.056 | -0.037 | 0.000 | 0.064 | 0.002 | 3.241 |
| 13 | Manganese | 3.126 | 9.143 | 2.599 | 0.775 | 3.078 | 0.341 | 0.415 | 4.113 | 0.107 | -0.073 | -0.090 | -0.096 | 0.000 | -0.001 | 3.671 |
| 14 | Phosphorus | 3.699 | 9.310 | 2.497 | 0.765 | 3.473 | 0.325 | 0.236 | 3.988 | 0.406 | -0.011 | -0.068 | -0.110 | 0.073 | 0.000 | 3.520 |
| 15 | Grain Yield/plant | 6.113 | 3.784 | 0.279 | 0.072 | 5.399 | -0.007 | 0.195 | 1.124 | 0.777 | -0.079 | -0.021 | -0.011 | 0.123 | 0.006 | 0.000 |

Table 2: Genetic advance estimates (ΔG_i) in 15 cases of restricted selections for 60 genotypes of foxtail millet [*Setaria italica* (L.) Beauv.] when inverse of means are used as economic weights

| Case | Traits | Days to 50% flowering | Plant height | Panicle length | Prod. tillers per plant | Days to maturity | Test wt | Protein | Carbohydrate | Calcium | Iron | Zinc | Copper | Manganese | Phosphorus | Grain Yield/plant |
|------|-------------------------|-----------------------|--------------|----------------|-------------------------|------------------|---------|---------|--------------|---------|-------|-------|--------|-----------|------------|-------------------|
| 1 | Days to 50% flowering | 0.000 | 8.803 | 2.855 | 0.768 | -0.180 | 0.347 | -0.035 | 3.721 | 0.346 | 0.362 | 0.065 | -0.013 | 0.078 | 0.021 | 3.738 |
| 2 | Plant height | 3.739 | 0.000 | 1.421 | 0.505 | 2.286 | 0.256 | 0.500 | 2.932 | 0.757 | 0.580 | 0.065 | 0.013 | 0.086 | 0.015 | 2.500 |
| 3 | Panicle length | 5.254 | 0.601 | 0.000 | 0.286 | 3.539 | 0.110 | 0.290 | -0.077 | 0.480 | 0.571 | 0.246 | 0.040 | 0.135 | 0.019 | 1.297 |
| 4 | Prod. tillers per plant | 2.625 | 2.196 | 0.870 | 0.000 | 1.237 | 0.096 | 0.298 | 1.513 | 0.321 | 0.763 | 0.257 | 0.065 | 0.120 | 0.036 | 0.933 |
| 5 | Days to maturity | 0.392 | 8.325 | 2.763 | 0.749 | 0.000 | 0.339 | 0.023 | 3.640 | 0.349 | 0.383 | 0.074 | -0.007 | 0.082 | 0.022 | 3.678 |
| 6 | Test wt | 3.221 | 3.528 | 0.590 | 0.174 | 1.702 | 0.000 | 0.005 | 0.076 | 0.625 | 0.491 | 0.257 | 0.140 | 0.150 | 0.026 | 0.592 |
| 7 | Protein | 1.851 | 7.950 | 2.581 | 0.758 | 1.289 | 0.335 | 0.000 | 3.495 | 0.426 | 0.383 | 0.072 | -0.015 | 0.097 | 0.019 | 3.610 |
| 8 | Carbohydrate | 2.690 | 6.688 | 1.485 | 0.583 | 1.805 | 0.217 | 0.087 | 0.000 | 0.284 | 0.441 | 0.193 | 0.026 | 0.107 | 0.024 | 2.590 |
| 9 | Calcium | 1.841 | 8.115 | 2.575 | 0.749 | 1.241 | 0.339 | 0.134 | 3.429 | 0.000 | 0.389 | 0.087 | -0.009 | 0.080 | 0.020 | 3.675 |
| 10 | Iron | 1.822 | 8.739 | 2.697 | 0.828 | 1.391 | 0.343 | 0.163 | 3.655 | 0.469 | 0.000 | 0.029 | -0.003 | 0.083 | 0.017 | 3.716 |
| 11 | Zinc | 1.940 | 7.760 | 2.680 | 0.787 | 1.394 | 0.349 | 0.143 | 3.772 | 0.495 | 0.345 | 0.000 | -0.027 | 0.090 | 0.019 | 3.701 |
| 12 | Copper | 1.948 | 7.707 | 2.548 | 0.746 | 1.314 | 0.330 | 0.103 | 3.448 | 0.398 | 0.372 | 0.074 | 0.000 | 0.092 | 0.019 | 3.560 |
| 13 | Manganese | 1.177 | 7.548 | 2.734 | 0.780 | 0.781 | 0.362 | 0.345 | 3.698 | 0.034 | 0.317 | 0.047 | 0.005 | 0.000 | 0.018 | 3.878 |
| 14 | Phosphorus | 2.194 | 7.505 | 2.555 | 0.797 | 1.626 | 0.342 | 0.117 | 3.653 | 0.443 | 0.347 | 0.068 | -0.021 | 0.090 | 0.000 | 3.756 |
| 15 | Grain Yield/plant | 3.559 | 1.029 | 0.289 | 0.025 | 2.173 | -0.005 | -0.003 | 0.220 | 0.839 | 0.556 | 0.208 | 0.147 | 0.162 | 0.035 | 0.000 |

Conclusion

Restricted selection was carried out by restricting the selection for only fourteen out of fifteen characters without effecting any change in the fifteenth character. In all such fifteen possible restriction selections, the trait plant height recorded maximum estimate of genetic advance in 11 out of 15 cases. This phenomenon was observed in both cases *i.e.*, when equal economic weights are used as well as when inverse of means are used as economic weights of the respective characters.

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