RECURRENT S$_1$ PROGENY SELECTION TO IMPROVE PEARL MILLET

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(Manuscript received 29 March 2006)

Abstract

Recurrent S$_1$ breeding program was carried out during the period from 1997 to 2003 summer seasons to develop synthetic variety within eighteen populations of pearl millet. Seven populations were selected to establish Syn$_0$ and Syn$_1$. The resulted synthetics were evaluated against the original parents in two seasonal trials. Syn$_1$ was significantly higher than the best parent by 14.4% for fresh yield and 25.2 for dry yield over all seasons. Heritability in broad sense expressed high values for fresh and dry yields (94.4 and 94.0%) indicating less effects by environments and largely by the additive effects of genes. Environmental effects were 5.6% for fresh yield and 6.0% for dry yield. S$_1$ selection and cross-pollination in each cycle of selection has led to an increase averaged 3.9 units for fresh yield represents 15.4% and 0.83 units for dry yield which represents 19.5% as expected genetic advance over the general average. The genotypic coefficient of variation over the two years of evaluation varied from 0.234% (dry yield) to 5.04% (fresh yield) and the phenotypic coefficient of variation varied from 0.249% (dry yield) to 5.34% (fresh yield).

Abbreviations: C, Cycle of selection. S$_1$, First selfed generation. Syn$_0$, first recombination generation. Syn$_1$, second recombination generation. GCV and PCV, genotypic and phenotypic coefficients of variability. H^{2}b, heritability in broad sense Bp, base population.

INTRODUCTION

Pearl millet (*Pennisetum glaucum L.*) is grown principally for grains in the tropical and subtropical areas of Africa and India subcontinent. Although pearl millet, is traditionally a small grain crop, traits associated with adoption to marginal environments makes it as a multi-cut forage crop. It has been grown most extensively as a forage crop in many countries. In Egypt, pearl millet plays an important role to increase forage demand in summer seasons. Developing high yielding cultivars characterized with resistance and or tolerant to biotic and abiotic stresses of forage crops is one of the important mandates of the Forage Crops Res. Dept.

As the total area cultivated with summer forage is limited, it is sincerely needed to increase the total production of forage of such area by releasing highly productive new varieties of summer crops (Bidinger and Raju, 2000).

The success of population breeding methods, particularly recurrent selection in improvement of maize populations, has led to its application in improvement of other cross- pollinated crops.

Modified half-sib method is described as an aid to adopt recurrent selection methods in pearl millet (Singh *et al.* 1988).

In recurrent selection, large amount of genetic variability can be readily obtained by hybridization between many parents. This variability can be maintained in a population by using recurrent intermitting whereas the population is improved by selection. This allows repeated opportunities for selection, recombination and transgressive segregation. The most important aspect of a successful recurrent selection program is the choice of parents to form a base population with large amount of desirable genetic variability (Singh *et al.*1988).

Heritability estimates provide information on the transmission of characters from parents to progenies, such estimates facilitate evaluation of hereditary and environmental effects in phenotypic variation and thus aid in selection. Also, it can be used with genetic advance to predict advance under selection as mentioned by johanson *et al.*, (1955) and Bakheit, (1986) that, heritability estimates along with genetic advance would be helpful in predicting gain under phenotypic selection than heritability estimates alone. So that, the breeder can anticipate improvement from different types and intensities of selection, (Soliman, 1994).

The objective of this research was to develop a synthetic variety through practicing recurrent selection.

MATERIALS AND METHODS

This investigation was carried out during the period from 1997 to 2003. It started at Ismailia Res. Station to evaluate the fresh and dry yields for 18 populations of pearl millet which were collected by the Forage Crops Res. Dept. (ARC) from Upper Egypt (Kom-Ombo and Aswan) several years before starting this investigation and marked with serial numbers.

The trial was carried out in a randomized complete block design with three replicates. The plot size was 1.2 x 4 m and the seeds were drilled in 6 rows 20 cm apart at the rate of 15 kg / fed.

According to the analysis of variance data, the highest yielding seven populations were selected to form a base for new synthetic variety using two cycles of recurrent S_1 selection method at Giza Res. Station. In the summer season of 1998, each of the seven selected populations was planted in a plot of 36 m^2 and plants were spaced of 25 cm. Later on, 56 plants were visually selected in each population according to its vigor. The main panicle of the selected plants were bagged and tripped to obtain the selfed seeds (S_1).

In 1999 equal amount of selfed seeds from each selected plant were bulked for each population and sown in isolation for natural cross pollination. The plots were

planted in the upwind edge of different sorghum fields to limit the effects of pollen from other sources.

From each progeny, the seeds from the pollinated panicles were bulked to form the first recombination generation (Syn_0). In 2000 and 2001 summer seasons, the same previous procedures were followed to obtain (Syn_1) of the C_2 cycle of recurrent selection.

In 2002 and 2003 summer seasons, Syn_0 and Syn_1 of recurrent selection were evaluated against the original seven populations in a randomized complete bock design with three replicates in Seds Res. Station. The plot size was 1.2 x 4 m with six rows, 20 cm apart, the seeds were hand drilled at the rate of 15 kg / fed. and the cultural practices were applied as recommended. Three cuts were taken during each season of evaluation.

Fresh and dry forage yields (t / fed.) were determined and the data were analyzed using IRRISTAT computer program.

The genetic parameters were estimated, such as genotypic and phenotypic variances (∂^2_g and ∂^2_p), according to Al-Jibouri et $al.$ (1958), genotypic and phenotypic coefficients of variability (P.C.V. and G.C.V.) according to Burton (1952), heritability in broad sense (H^2_b) according to Burton and Dezane (1953) and genetic advance.

RESULTS AND DISCUSSION

The means of base populations for three cuts of fresh and dry yields are presented in Table (1). The analysis of variance for the tested populations expressed significant differences among them for fresh and dry yields. The highest yielding seven populations in ascending order were number 9, 3, 5, 15, 10, 4 and number1. The fresh yields ranged from 16.22 to 18.06 t/fed. and from 2.87 to 3.19 t /fed. for dry yield.

Response to selection and cross pollination

The analysis of variance for each year of evaluation and the combined showed significant differences between years and between genotypes. The interaction of genotypes X years was not significant indicating that the entries under investigation were not greatly affected by environments, as mentioned by Bakheit (1986), where he reported that mean of dry matter and protein did not show significant interaction with environment and this implied environment may not affected those traits (Table 2).

Comparisons of Syn_0 and Syn_1 against the base populations for fresh and dry yields in the two summer seasons (2002 and 2003) and there combined are presented in Table (3).

Enormous improvement was achieved in fresh yield after two cycles of selection. In both seasons, the differences between Syn_0 and Syn_1 were not significant and Syn_1 was significantly higher than all the base populations. Syn_0 and Syn_1 were higher than the over mean by 13.4% and 18.8% in the first year and 10.3% and 14.1% in the second year for fresh yield.

The same trend of improvement was recorded for dry yield in the first and second years of evaluation. The combined analysis revealed that Syn_1 recorded the highest fresh yield (29.49 t/fed.) which was not significantly different from Syn_0 and was significantly higher than all the base populations.

Syn_1 recorded the highest dry yield (5.26 t/fed.) which was significantly different from Syn_0 and all the base populations,

The results are in agreement with the finding of Bidinger and Raju (2000) who reported an increase in individual grain mass in the modern open-pollinated millet ICMS 7703, by two cycles of recurrent S_1 progeny selection.

Guzman and Kendall (2000) reported that, recurrent selection is designed to improve population performance and maintain genetic variability for continued selection.

In addition results were supported by Bakheit and El-Nahrawy (1997) who indicated that, comparison between the base populations and populations developed by recurrent selection showed significant response to selection for forage yield in alfalfa for each cycle.

Moreover, El-Nahrawy and Bingham (1989) reported that, inbreeding and selection in alfalfa may lead to the accumulation of favorable genes and elimination of the deleterious genes.

Heritability, genotypic and phenotypic of variability

Genetic parameters in terms of heritability in broad sense (H^2_b), genotypic and phenotypic variance (∂^2_g and ∂^2_p), genotypic and phenotypic coefficient of variability (G.C.V. and P.C.V.) and genetic advance for fresh and dry yield are presented in Table (4).

The heritability in broad sense expressed high values for fresh and dry matter (94.4% and 94.0%) indicating that fresh and dry yields resulted from two cycles of selection were less affected by environment and were largely influenced by the additive effects of genes and the improvement in these traits may be achieved through phenotypic selection, as mentioned by Johanson et al., (1955) and Bakheit (1986).

The environmental variation ($(\partial^2_p - \partial^2_g) / \partial^2_p \cdot 100$) were 5.6% for fresh yield and 6.0% for dry yield, indicating that these traits are relatively less affected by environment as mentioned by Bakheit,(1986).

The estimates of expected gain from selection show that two cycles of selection and randomly open pollination for the selected parents in each cycle, has led to an increase by 3.9 units for fresh yield which represents 15.4% as expected genetic advance and 0.83 units for dry yield represents 19.5% over the general average.

The phenotypic coefficient of variation (P.C.V.) over two years of evaluation varied from 0.249% for dry yield to 5.04% for fresh yield, which reflecting high estimates of broad sense heritability.

The obtained results are in line with those reported by El-Shahawy *et al.*, (2000), Haggag *et al.*, (2000) and Abdel Galil *et al.*, (2001).

In conclusion, recurrent selection method seems effective in improving pearl millet population and helpful technique to produce synthetic varieties, where, a developed Syn_1 could be obtained and may out yield component populations. This synthetic would be tested against the commercial varieties and it may be needed to carry out further cycles of selection to raise its productivity.

Table 1. Fresh and dry yields (t/fed.) for some tested local ecotypes of pearl millet in 1997 summer season.

Char / Pop	Fresh yield				Dry yield			
	Cut1	Cut2	Cut 3	Total	Cut1	Cut2	Cut3	Total
BP_1	4.51	6.96	7.57	16.22	0.62	1.22	1.03	2.87
BP_2	4.15	6.56	4.65	15.36	0.52	1.18	1.02	2.72
BP_3	5.62	7.68	4.36	17.65	0.79	1.36	0.96	3.10
BP_4	5.05	7.40	3.99	16.45	0.71	1.35	0.86	2.91
BP_5	5.50	7.60	4.36	17.46	0.74	1.41	0.89	3.04
BP_6	4.00	6.46	3.15	13.61	0.53	1.20	0.70	2.43
BP_7	3.56	6.10	2.95	12.61	0.45	1.12	0.64	2.21
BP_8	4.36	6.61	3.66	14.63	0.57	1.22	0.79	2.59
BP_9	5.46	8.01	4.59	18.06	0.76	1.43	0.99	3.19
BP_{10}	5.37	7.45	4.02	16.84	0.72	1.36	0.88	2.97
BP_{11}	5.05	6.82	3.62	15.50	0.68	1.26	0.80	2.74
BP_{12}	4.58	7.01	3.49	15.08	0.60	1.30	0.76	2.66
BP_{13}	4.37	6.69	3.06	14.12	0.59	1.23	0.68	2.50
BP_{14}	3.57	6.04	2.78	12.39	0.46	1.09	0.60	2.14
BP_{15}	5.50	7.73	3.77	17.00	0.74	1.39	0.84	2:97
BP_{16}	4.48	7.18	3.45	15.11	0.60	1.34	0.75	2.70
BP_{17}	4.82	6.50	3.54	14.86	0.62	1.20	0.78	2.60
BP_{18}	4.95	7.30	3.49	15.74	0.66	1.34	0.76	2.76
Mean	4.72	7.01	3.76	15.48	0.63	1.28	0.82	2.727
L.S.D	0.96	1.24	0.97	2.72	0.13	0.22	0.21	0.49

Table 2. Means squares for fresh and dry yield over two years of evaluation.

S.O.V.	d.f.	Fresh yield	Dry yield	Expectation mean squares	
		M.S.			
Rep	2	8.883*	0.297*		
Year	1	59.137*	1.992*		
Genotypes	8	32.034*	1.49*	M_3	$\partial^2_e + r\partial^2_{gy} + r\,y$
Geno-years	8	1.487	0.0892	M_2	$\partial^2_e + r\partial^2_{gy}$
Error	34	1.800	0.0893	M_1	∂^2_e
Total	53	7.666	0.345		

Where, r = number of replicates, g = number of genotypes, y = number of years, M_1 = error mean square, M_2 = genotypes by year mean squares and M_3 = genotypic mean square.

Table 3. Fresh and dry yields evaluated for Syn_0, Syn_1 and the seven base populations (BP) of pearl millet (t/fed.) and their combined in 2002 and 2003 seasons.

Entries	2002		2003		Combined	
	Fresh yield	Dry yield	Fresh yield	Dry yield	Fresh yield	Dry yield
Syn_0	27.56	4.73	29.11	5.14	28.33	4.94
Syn_1	28.87	5.18	30.11	5.34	29.49	5.26
BP_1	21.11	3.68	24.89	4.17	22.99	3.93
BP_3	24.56	3.97	26.99	4.42	25.77	4.20
Bp_4	21.12	3.54	23.56	3.93	22.34	3.74
Bp_5	24.22	3.97	25.88	4.29	25.06	4.13
BP_9	25.11	3.97	25.67	4.07	25.39	4.02
BP_{10}	22.78	3.66	25.99	4.59	24.39	4.13
BP_{15}	23.31	3.91	25.40	4.13	24.42	4.02
Mean	24.31	4.07	26.40	4.45	25.38	4.26
L.S.D.	2.6	0.45	2.16	0.596	1.57	0.133

Table 4. Estimates of genetic parameter[*].

Char.	x	∂^2_g	$\partial^2 p$	G.C.V.	P.C.V.	H^2_b	G.a.	G.a.%
Fresh	25.38	5.04	5.34	8.8	9.1	94.4	3.9	15.4
Dry	4.26	0.234	0.249	11.4	11.7	94.0	0.83	19.5

* Genotypic variance (∂^2_g), phenotypic variance ($\partial^2 p$), genotypic coefficient of variation (G.C.V.), phenotypic coefficient of variation (P.C.V.), heritability (H^2_b), genetic advance as units (G.a.), and genetic advance as percentage of mean (G.a.%).

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الانتخاب التكراري فى نسل الجيل الأول الذاتى لتحسين دخن العلف

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تم تنفيذ برنامج لتربية دخن العلف باستخدام الانتخاب التكراري لـدورتين انتخـابيتين فـى الجيل الذاتى الأول، وقد تم تنفيذ هذا البرنامج خلال الفترة من سنة ١٩٩٧ الى ٢٠٠٣ وذلك بهـدف إنتاج صنف تركيبي من عشائر محليه تم جمعها بمعرفة قسم بحوث محاصيل العلف.

وقد أوضحت نتائج تقييم الصنف التركيبي مقارنـة بالأبــــــاء الأصــــلية (سبع عشائر) تفوق الصنف التركيبي معنوياً على أحسن الأباء بنسـبة ١٤,٤ للمحصـول الأخضـر ٢٥,٢ للمحصول الجاف.

كما أظهرت النتائج أن درجة التوريث فى المدى الواسع للمحصـول الأخضـر ٩٤,٤% والمحصول الجاف ٩٤% بما يشير الى انخفاض التأثير البيئي وزيادة تأثير العوامل المضيفة كمـا أوضحت النتائج أن التحسين الوراثي المتوقع لصفة المحصول الأخضر ١٥,٤% والمحصول الجاف ١٩,٥%.

وعلى هذا فإنه يمكن تحسين إنتاجية عشائر دخن العلف باستخدام ألانتخاب التكراري فـى الجيل الذاتي الأول فى دورتين انتخابيتين واستنباط عشيره تركيبيه تتفوق على أحسن ألآباء وتكـون اساس لصنف تركيبى جديد يتم تطويره من خلال استمرار ألانتخاب التكراري لأجيال متقدمه .