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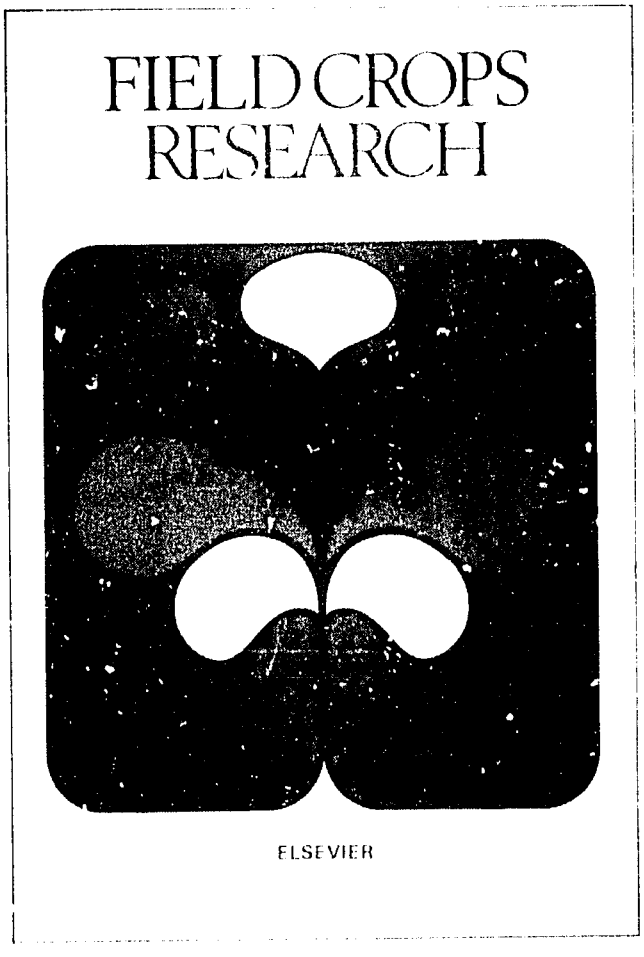

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Field Crops Research, 11 (1985) 161—170
Elsevier Science Publishers B.V., Amsterdam — Printed in The Netherlands

EFFECT OF CULTURAL TREATMENT ON QUALITY AND SUBSEQUENT PERFORMANCE OF PEARL MILLET SEED

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(Accepted 7 March 1985)

ABSTRACT

Okonkwo, J.C. and Vanderlip, R.L., 1985. Effect of cultural treatment on quality and subsequent performance of pearl millet seed. *Field Crops Res.*, 11: 161—170.

Pearl millet (*Pennisetum americanum* (L.) Leeke) generally exhibits low seed vigor which affects field establishment and grain yield. We studied the effect of tiller removal, spikelet removal, nitrogen fertilization, hill planting and head selection on seed quality, including density, protein, size, and weight. In subsequent experiments, seed produced under each cultural treatment was tested for vigor, field establishment and grain yield.

Spikelet removal and head selection generally increased seed quality: size, weight and, in 1 year, density. Only nitrogen consistently improved seed protein. Hill planting and tiller removal had little effect on seed quality. Greenhouse seedling performance of seeds from the treated plants showed few treatment differences, suggesting that small differences in seed quality may not be critical in seedling performance under good growing conditions. Spikelet removal and head selection increased field establishment and grain yield in most experiments. Influence of seed protein could not be separated from that of seed density and seed size in this study. Selection based on seed size may be more beneficial than selection based on head size.

INTRODUCTION

Pearl millet (*Pennisetum americanum* (L.) Leeke) is a major food crop in the semi-arid regions of Africa and Asia. It is better adapted to the low rainfall and high temperatures of these regions than most cereals (Brunken et al., 1977; Rachie, 1966). The relatively high protein content (Burton et al., 1972) is especially important to the people of the regions who rely on millet for food. However, millet characteristically has problems of low seed vigor, the result being poor field establishment and low grain yield (Mwageni and Vanderlip, 1978).

Gardner (1980) found that seed density and seed size of pearl millet were closely related to seedling emergence and grain yield. In switchgrass (*Panicum virgatum* L.), the germination percentage was 77 for

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TABLE 1

Seed production cultural treatments

Treatment	1980			1981			
	Dryland		Irrigated	Dryland		Irrigated	
	Senegal bulk population	Serere 3A	Senegal bulk population	Senegal bulk population	Serere 3A	Senegal bulk population	Serere 3A
Control	x	x	x	x	x	x	x
Tillers removed	x	x	x	x	x	x	x
Spikelet removed	x	x	x	x	x	x	x
Nitrogen	x	x	x	x	x	x	x
Hill planting	x	—	x	x	x	x	x
Head selection	—	—	—	x	x	x	x
Plant population	43 000		47 800	27 700		48 500	

large seeds and 22 for small seeds (Kneebone and Cremer, 1955). Although Maranville and Clegg (1977) reported higher germination percentage for large sorghum (*Sorghum bicolor* (L.) Moench) seed than small seed, they observed that seedling establishment and grain yield were not related to seed size or density. Sung and Delouche (1962) reported that high density rice (*Oryza sativa*, L.) seed had higher germination percentage, stouter seedlings, and produced more dry matter than low density seed. There is evidence that seed protein influences seedling vigor and grain yield (Evans and Bhatt, 1977). Ries et al. (1970) reported higher grain yield for wheat (*Triticum aestivum* L.) grown from high protein seeds than for that from low protein seeds especially on nitrogen deficient soils.

Objectives of this study were (1) to determine the effect of tiller removal, spikelet removal, nitrogen fertilization, hill planting, and head selection on seed quality factors including density, protein, size, and weight; and (2) to test the seed from each cultural treatment for subsequent seedling establishment and grain yield.

MATERIALS AND METHODS

Seed production experiments

Seed of Serere 3A (a cultivar) and the Senegal bulk population (developed at the Ft. Hays Branch Agricultural Experiment Station) was produced under spikelet removal, nitrogen fertilization, hill planting and head selection (Table 1) in a randomized complete block design in 1980 and 1981.

Control plots were planted at the appropriate plant population and no additional treatments applied.

Tillers were removed weekly, starting the third week after plants emerged and continuing until physiological maturity.

To allow more space for the developing seeds, spikelets were removed from a 1.5 cm-wide area from the top to the base of each millet panicle as it emerged from the flag leaf. Spikelets also were removed from the top 6 cm of each panicle to identify treated panicles. Plants received this treatment weekly until 75% of the plants reached physiological maturity. Only panicles that had not exceeded half-bloom were treated.

Ammonium nitrate was split-applied at the five leaf and boot stages for a total of 80 and 120 kg N/ha for the dryland and irrigated experiments, respectively.

Hill-planted plots received eight seeds per hill and seedlings were thinned to four after emergence. Plant spacings were four times as wide as in the control plots. Serere 3A did not receive this treatment in 1980.

Millet heads were selected visually on the basis of seed size during harvest. One head with the largest seeds was selected from every five heads in a row.

Fifty grams of seed from each management treatment were sieved with 0.32, 0.28, 0.24, 0.22, 0.18 and 0.10 cm sieves, consecutively. Seeds re-

TABLE 2

Effect of crop cultural treatment on diameter, density, and weight of pearl millet seeds

Treatment and year	Diameter			Weight			
	Dryland	Irrigated		Dryland		Irrigated	
	Senegal bulk population (mm)	Serere 3A (mm)	Senegal bulk population (mm)	Density (g cm²)	Senegal bulk population (g/1000)	Serere 3A (g/1000)	Senegal bulk population (g/1000)
1980							
Control	2.03 b*	2.40	2.11 b	1.23 a	8.4 b*	12.0 b	9.6 b
Tillers removed	1.98 b	2.43	2.20 ab	1.23 a	8.4 b	12.3 b	10.3 ab
Spikelets removed	2.17 a	2.50	2.27 a	1.22 b	9.2 a	12.9 a	10.8 a
Nitrogen	2.08 ab	2.44	2.06 c	1.23 a	8.5 b	12.3 b	10.1 b
Hill planted	2.15 a	—	2.10 b	1.23 a	9.2 a	—	9.6 b
Head selection	—	—	—	—	—	—	—
C.V.		3.4		0.6		3.7	
1981							
Control	2.34 c		2.40 b	1.20 b		10.9 b	
Tillers removed	2.38 b		2.42 b	1.20 b		11.4 b	
Spikelets removed	2.58 a		2.54 a	1.25 a		12.8 a	
Nitrogen	2.34 c		2.40 b	1.22 b		11.3 b	
Hill planted	2.40 b		2.40 b	1.18 c		11.1 b	
Head selection	2.53 a		2.54 a	1.26 a		13.0 a	
C.V.		2.09		1.8		5.5	

*Duncan's multiple range test: means with the same letter within a column are not significantly different. Alpha level 0.05.

tained on each sieve were multiplied by the sieve size, summed and divided by the seed number in the 50-g seed sample to determine average seed diameter. We used the water displacement method (Bartee and Krieg, 1974) to determine seed density. Seed protein and seed weight also were determined.

Field and greenhouse experiments

In 1981/82 we tested the seed, produced in 1980/81 from each cultural treatment, for vigor, field establishment and grain yield at Garden City, Manhattan, and St. John, KS. One hundred seeds were planted per 7.6 m row, 0.75 m apart in a randomized complete block design with four replications. Emergence counts were taken 7 and 21 days after planting. We used the last count as a measure of seedling establishment. Vigor index was calculated from the procedure reported earlier (Hanumaiah and Andrew, 1973). To determine vigor index, emergence counts were taken daily for 5 days. We weighed grain from each plot and adjusted the moisture to 12.5% to determine grain yield. Seedling vigor and establishment were determined under greenhouse conditions also. Twenty seeds from each treatment were planted 2 cm deep and 3.6 cm apart in rows 4.2 cm apart in each wooden flat containing sandy loam soil. Emergence counts were taken as in the field to determine seedling vigor and establishment. The design was split-plot with varieties as main plots and treatments as sub-plots. Average air temperature was 28°C.

RESULTS AND DISCUSSION

Spikelet removal and hill planting increased seed diameter and seed weight (Table 2) of Senegal bulk population in the dryland experiment in 1980. Seed diameter of Serere 3A was not affected. Spikelet removal improved the seed characteristics of both genotypes in irrigated experiments (Table 2). There was an average of two plants per hill instead of the designed four on the dryland experiments because of poor plant establishment, which may account for the effect of hill planting on seed diameter and seed weight. There were variety X treatment interactions for seed diameter and seed weight in 1980 (Table 2), suggesting differences in varietal response to cultural treatments. Except where interactions are significant, each table shows the average for the varieties and irrigations. Some panicles withered after the spikelets were removed in 1980, probably due to the hot and dry summer but not in 1981. This might have caused the reduction of seed density in 1980 (Table 2).

Spikelet removal and head selection consistently increased seed diameter, density and weight in 1981 (Table 2). Tiller removal and hill planting increased seed diameter in the dryland experiment in 1981, but not in the irrigated experiments (Table 2). Spikelet removal and nitrogen increased seed protein of Senegal bulk population in both 1980 and 1981 (Table 3). Only

TABLE 3

Effect of cultural treatment on seed protein of pearl millet

Treatment	% Protein						
	1980			1981			
	Dryland		Irrigated	Dryland		Irrigated	
	Senegal bulk population	Serere 3A	Senegal bulk population	Senegal bulk population	Serere 3A	Senegal bulk population	Serere 3A
Control	10.1 c*	9.0 c	9.8 c	12.0 c	12.0 b	11.9 c	9.9 b
Tillers removed	9.7 c	10.1 b	10.4 b	13.2 b	13.2 b	13.4 b	11.0 b
Spikelets removed	10.7 b	9.8 b	10.4 b	13.4 b	12.8 b	12.9 b	10.5 b
Nitrogen	12.6 a	11.6 a	12.7 a	16.6 a	15.5 a	16.4 a	13.8 a
Hill planted	9.7 c	—	9.4 c	12.8 b	12.2 b	11.6 c	10.0 b
Head selection	—	—	—	12.6 b	11.9 b	12.3 b	10.1 b
C.V.		4.1			6.1		

*Duncan's multiple range test: means with the same letter within a column are not significantly different. Alpha level 0.05.

TABLE 4

Effect of cultural treatment on pearl millet seed as indicated by subsequent seedling establishment and grain yield, 1981 (1980 seed)

Treatment	% Seedling establishment	St. John: grain yield (kg/ha)			Manhattan: % seedling establishment			Vigor index	Grain yield (kg/ha)
		Dryland		Irrigated	Dryland		Irrigated		
		Senegal bulk population	Serere 3A	Senegal bulk population	Senegal bulk population	Serere 3A	Senegal bulk population		
Control	37 b*	2210 bc	2114 b	2129 c	52 c	63	52 c	20.6 b	3039 b
Tillers removed	39 b	2079 c	2535 b	1997 c	57 b	59	56 bc	22.1 a	2956 b
Spikelets removed	48 a	3354 a	2095 b	3459 a	63 a	61	65 a	23.3 a	3777 a
Nitrogen	45 ab	2671 b	3039 a	2671 b	61 ab	62	58 b	22.9 a	3126 b
Hill planted	40 b	2409 bc	—	2117 c	52 c	—	57 b	20.5 b	3463 ab
C.V.	12.4		20.0					6.5	19.8

*Duncan's multiple range test: means with the same letter are not significantly different. Alpha level 0.05.

TABLE 5

Effect of cultural treatment on pearl millet seed as indicated by subsequent seedling establishment and grain yield, 1982 (1980 and 1981 seed)

Treatment	St. John		Manhattan			Garden City	
	% Seedling establishment	Grain yield (kg/ha)	% Seedling establishment	Vigor index	Grain yield (kg/ha)	% Seedling establishment	Grain yield (kg/ha)
Control	54 c*	1742 c	56 bc	14.7 c	3793	34 b	1581 b
Tillers removed	59 b	1788 c	54 c	15.2 bc	3685	35 b	1695 b
Spikelets removed	59 b	1998 b	56 bc	15.9 b	4077	42 a	1907 a
Nitrogen	63 a	1824 bc	58 ab	16.6 a	3964	37 b	1693 b
Hill planted	52 c	1717 c	56 bc	15.6 b	3943	34 b	1684 b
Head selection	62 a	2242 a	59 a	16.9 a	4126	43 a	2119 a
C.V.	10.1	17.5	8.5	8.7	13.3	13.6	20.3

*Duncan's multiple range test: means with the same letter are not significantly different. Alpha level 0.05.

nitrogen consistently increased seed protein of Serere 3A in 1980 and 1981 (Table 3).

Results of the greenhouse experiments showed few treatment differences and are not presented. Spikelet removal increased subsequent field establishment and grain yield of Senegal bulk population at St. John in 1981 (Table 4). Head selection, in addition, consistently improved seedling establishment and grain yield at St. John and Garden City in 1982 (Table 5). Nitrogen treatment increased subsequent grain yield of Serere 3A and Senegal bulk population (irrigated) at St. John, but not seedling establishment (Table 4). It was difficult in this study to separate the effects of seed protein from those of seed density and size. Nitrogen, tiller removal (dryland) and spikelet removal increased seedling establishment and seedling vigor of Senegal bulk population, but only spikelet removal increased grain yield at Manhattan in 1981 (Table 4). Growing conditions were especially good at Manhattan in 1982, but only head selection improved both seedling vigor and establishment (Table 5). None of the cultural treatments improved grain yield.

Our results showed that head selection and spikelet removal could be effective in seed quality improvement. Ease of head selection makes this an attractive method. Selection based on seed size rather than head size may substantially increase farmers' benefits from selection management. Effect of seed quality on crop performance, as observed under greenhouse conditions and in the field in 1982 at Manhattan, may be greater under poor than good growing conditions. It was difficult to separate the influence of seed protein on subsequent crop performance from that of seed size and seed density.

ACKNOWLEDGEMENT

Contribution 84-350-J, Agronomy Department, Kansas Agricultural Experimental Station, Manhattan, KS 66506. Cooperative project between contract AID/DSAN-G-D149, Agency for International Development, Title XII, INTSORMIL, and Kansas State University.

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