Fiber Diameter Measurements of Fine-wool Rams on Performance Test[1,2]

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Summary

Average fiber diameter (AFD), standard deviation of fiber diameter (SD) and coefficient of variation of fiber diameter (CV) were determined for core-sampled pre-test fleeces, side and britch on-test samples and core-sampled post-test fleeces for 531 rams participating in the Texas Agricultural Experiment Station's Ram Performance Test during the years 1994, 1995 and 1996. Pre-test fleece measurements were shown not to provide a good indication of the AFD of wool grown during the test. Further, although side samples and post-test core samples were significantly correlated (r^2 = 0.75) in terms of AFD, side samples were coarser (1.33 µm; P < 0.0001) than whole fleece core samples. Britch and side AFD differences were not indicative of whole fleece variability of AFD (r^2 < 0.04). These last two observations have important implications for the fine-wool ram performance tests conducted by the Texas Agricultural Experiment Station (TAES; San Angelo, TX) and the University of Wyoming (UW; Laramie, WY).

Key words: average fiber diameter, performance test, ram.

Introduction

Average fiber diameter and standard deviation of fiber diameter are important price-determining characteristics of raw wool because (together with length characteristics) they govern the size and uniformity of yarn, the efficiency of yarn production and ultimately the type of product that can be manufactured from a particular lot of wool (Iman et al., 1990; Lupton, 1995). Consequently, AFD and fiber diameter variability, either SD or CV, are two of the variables used to assess overall merit of fine-wool rams on performance test (Riley et al., 1996). In the TAES Performance Test (Shelton and Lewis, 1986; Waldron and Lupton, 1996), the AFD of a side sample is used to estimate AFD of the fleece grown during the test. The difference between AFD of a britch sample and that of the corresponding side sample is used as an indicator of fiber diameter variability. In addition, the AFD of side and britch samples constitute two independent culling levels (24.94 and 26.39 µm, respectively) for certification of rams in the American Rambouillet Sheep Breeders' Association. Previous work (Lupton et al., 1990) on a limited number (100) of rams participating in the 1989 TAES test and rams (78) in the 1989 UW performance test (Iman et al., 1990) indicated that AFD of side sample was a good indicator (r = 0.89) of AFD of whole fleeces and that the difference in AFD between britch and side was significantly but only poorly correlated (r = 0.15) with whole-fleece CV of fiber diameter. In contrast, the CV of fiber diameter of the whole fleece core sample was moderately correlated (r = 0.45) to the CV of fiber diameter of the side sample. One implication for fine-wool ram testing and selection of stud rams was that the CV of fiber diameter of the whole fleece is not a sensitive indicator of coarse britch wool (and vice versa).

The current three-year study was designed to establish the relationships between AFD and variability of fiber diameter for fleeces collected at the beginning of performance tests, side and britch samples collected during the performance tests and whole fleeces shorn at the end of the tests. By measuring fibers on three different sets of rams participating in three separate performance tests, the effect of year on the various measures of fiber diameter was also determined. Results from this experiment permit informed recommendations to be

[1] This article reports research conducted by the Texas Agricultural Experiment Station, The Texas A&M University System, San Angelo, TX.

[2] Financial support from the Cooperative State Research, Education and Extension Service, U.S. Department of Agriculture, under agreement numbers 92-34148-6989 and 95-34148-1326 is gratefully acknowledged.

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made concerning the use of the most appropriate measures of fiber diameter distribution in fine-wool selection programs and/or index equations.

Materials and Methods

Rams participating in the 1994, 1995 and 1996 TAES Ram Performance Tests were routinely shorn at the beginning of the test. The "pre-test" fleeces were expected to be variable as a result of different pre-test management practices, environments, ages and genetic backgrounds of the rams. Thirty-two half-inch core samples were removed from each pre-test fleece (Johnson and Larsen, 1978). Pre-test core samples (PRC) were washed and dried (ASTM, 1995), conditioned, sub-sampled with a 2-mm mini-corer and the resulting sub-samples were measured for AFD, SD and CV using an Optical Fibre Diameter Analyser (OFDA; IWTO, 1995). Ninety-eight days into the performance tests, mid-side (S) and britch (B) samples were removed from each ram. These wool samples were sub-sampled close to the base of the staple using a 2 mm "snippeter" device. This sampling site was chosen because it is known that AFD of a side sample of a ram on test tends to be constant after the first 28 days (Schafer, 1992; Bohnert, 1994). The resulting 2-mm snippets were cleaned with solvents (1, 1, 1-trichloroethane, ethanol and acetone), dried, conditioned and measured for AFD, SD and CV using the OFDA. At the end of the 143-day performance tests, each ram was shorn. These fleeces were post-test core sampled (POC) and measured in an identical manner to the pre-test fleeces.

Data were analyzed to provide simple statistics (mean, SD, CV) for each variable measured and simple linear regression analyses and analyses of variance were performed on the data using the MEANS, REG and GLM procedures of SAS (SAS, 1992). For these analyses it was assumed that all rams were genetically independent of each other. In fact, this was not the case. Several rams each year had common sires and a few had common dams. We considered that these few relationships would not significantly affect the results of our analyses.

Results and Discussion

Tables 1, 2 and 3 show least squares means and standard errors by year for AFD, SD and CV of the PRC, S, B and POC wool samples, respectively. Overall, the AFD of the PRC did not differ among years (P > 0.05). In

Table 1. Least squares means (and standard errors) of average fiber diameters by year.[a]

Year	N	PRC, µm	S, µm	B, µm	POC, µm
1994	201	19.95 (0.10)	23.71[b] (0.13)	26.97[b] (0.17)	22.06[c] (0.11)
1995	169	20.20 (0.11)	23.27[c] (0.15)	26.23[c] (0.18)	22.43[b] (0.12)
1996	161	20.22 (0.11)	23.94[b] (0.15)	26.56[b,c] (0.18)	22.48[b] (0.12)

[a] N = number of rams in performance test; PRC = pre-test core sample; S = side sample; B = britch sample; POC = post-test core sample.
[b,c] Column means having different superscripts differ (P < 0.05).

Table 2. Least squares means (and standard errors) of standard deviation of fiber diameter by year.[a]

Year	N	PRC, µm	S, µm	B, µm	POC, µm
1994	201	4.63[b] (0.04)	4.34[b] (0.04)	5.66[b] (0.06)	4.42 (0.04)
1995	169	4.04[c] (0.05)	3.76[d] (0.04)	4.54[c] (0.07)	4.48 (0.04)
1996	161	4.05[c] (0.05)	3.97[c] (0.04)	4.72[c] (0.07)	4.43 (0.04)

[a] N = number of rams in performance test; PRC = pre-test core sample; S = side sample; B = britch sample; POC = post-test core sample.
[b,c,d] Column means having different superscripts differ (P < 0.05).

Table 3. Least squares means (and standard errors) of coefficient of variation of fiber diameter by year.1

Year	N	PRC, µm	S, µm	B, µm	POC, µm
1994	201	23.21[b] (0.19)	18.31[b] (0.12)	20.95[b] (0.19)	20.04 (0.14)
1995	169	20.00[c] (0.21)	16.17[d] (0.13)	17.31[c] (0.21)	20.00 (0.15)
1996	161	20.03[c] (0.21)	16.57[c] (0.13)	17.33[c] (0.21)	19.72 (0.16)

[a] N = number of rams in performance test; PRC = pre-test core sample; S = side sample; B = britch sample; POC = post-test core sample.
[b,c,d] Column means having different superscripts differ (P < 0.05).

contrast, mean side sample AFD in 1995 was less than 1994 or 1996 ($P < 0.05$). Britch AFD exhibited a similar pattern but core samples from the whole fleece indicated that 1994 fleeces were finer ($P < 0.05$) than the other two years. Interestingly, the amount of fleece coarsening that occurred in each test period was not affected by year (POC – PRC = 2.1, 2.2 and 2.3 µm in 1994, 1995 and 1996, respectively; $P = 0.39$). To a very close approximation, the overall average fineness of the rams at the start of the test was not different among years. Every effort was made to manage and feed the rams on test in an identical manner in each year of the experiment. Nevertheless, year effects on all measures of fiber diameter (except the above-mentioned measures of coarsening) were significant, indicating that other environmental factors may affect the performance of the rams. Thus, care is required when comparing among-year performance of rams. Such comparisons are best made using percentage deviations from an annual mean for the particular trait being considered.

Table 4. Least squares means of average fiber diameter, standard deviation and coefficient of variation of various wool samples taken from 531 ram fleeces.

Item	PRC[a]	S[b]	B[c]	POC[d]
AFD, µm	20.11[h]	23.64[f]	26.61[e]	22.30[g]
SD, µm	4.27[g]	4.04[h]	5.02[e]	4.44[f]
CV, %	21.23[e]	17.10[h]	18.81[g]	19.95[f]

[a] PRC = pre-test core sample.
[b] S = side sample.
[c] B = britch sample.
[d] POC = post-test core sample.
[e-h]Row means having different superscripts differ ($P < 0.05$).

Table 5. Simple linear regression equations and coefficients of determination (r^2) for various measures of average fiber diameter, standard deviation and coefficient of variation.[a]

Dependent variable	Regression equation	r^2
Average fiber diameter		
S	AFD = 6.03 + 0.88 PRC	0.43
S	AFD = 5.15 + 0.67 B	0.74
S	AFD = –0.61 + 1.09 POC	0.75
Standard deviation		
S	SD = 2.19 + 0.43 PRC	0.27
S	SD = 2.01 + 0.40 B	0.55
S	SD = 1.90 + 0.48 POC	0.21
Coefficient of variation		
S	CV = 11.10 + 0.28 PRC	0.21
S	CV = 9.15 + 0.42 B	0.47
S	CV = 11.24 + 0.29 POC	0.09
POC SD[b]	CV = 4.17 + 0.09 (B AFD[c] – S AFD[c])	0.04
POC CV[d]	CV = 19.48 + 0.15 (B AFD[c] – S AFD[c])	0.01

[a] S = Side sample; PRC = pre-test core sample; B = britch sample; POC = post-test core sample.
[b] SD = standard deviation of fiber diameter.
[c] AFD = average fiber diameter.
[d] CV = coefficient of variation of fiber diameter.

For the three-year period (Table 4), wool produced during the test (POC) was 2.20 µm coarser than that shorn from the animals at the start of the test. Britch samples were 2.97 µm coarser than side samples and side samples were 1.33 µm coarser than post-test core samples of the whole fleece (POC). The observed consistent coarseness of the side sample compared to the fleece as a whole is contrary to earlier observations on rams participating in performance tests. However, a similar observation has been reported previously for crossbred ewes under range conditions (Iman et al., 1990).

Typically the AFD of fibers produced on the side of the animals during the first 28 days of the performance test is 3.6 µm finer than those produced during the remaining time (Bohnert, 1994; Salisbury, 1996; Schafer, 1992). Assuming a similar differential in other body areas, it should not be surprising that the POC samples are invariably finer than the S samples. Yearly trends in SD of fiber diameter shown in Table 2 tend to follow closely the trends in AFD. The CV data (SD/AFD × 100) summarized in Table 3 confirms that the variability in side and britch samples is generally less than that observed for either of the core samples.

Although AFD of pre-test core, side, britch and post-test core samples differ, regression analyses confirmed that the measurements are significantly correlated. A selection of pertinent regression equations and their corresponding coefficients of determination (r^2) are given in Table 5. Only 43% of the variation in S AFD can be accounted for by the variability of PRC AFD (Table 5 and Figure 1). In contrast, 75% of the variation in S AFD is accounted for by variation in POC AFD (Table 5 and Figure 2). The two measures of variability of fiber diameter (SD and CV) invariably exhibit lower r^2 values than the corresponding AFD correlation.

The differences between side and britch AFD values were thought to be a reasonable indicator of variability of fiber diameter in the fleeces as a whole. The two regression equations at the bottom of Table 5 and Figure 3 show that such is not the case. This observation is in agreement with that made by Iman et al. in 1990. Measures of whole-fleece variability of fiber diameter are best determined by measuring representative core samples.

Conclusions

Pre-test fleece measurements did not provide a good indication of the average fiber diameter of wool grown during the performance test.

The average fiber diamber of side samples and post-test whole fleece core samples were significantly correlated. However, side samples were coarser than core samples.

Differences in average fiber diamber between side and britch samples were not indicative of whole fleece variability in fiber diameter.

Whole-fleece variability of fiber diameter is best determined by measuring representative core samples.

Implications

In terms of average fiber diameter and its associated variability, rams participating in the TAES and UW performance tests are being assessed using different criteria. Because these criteria are used to certify the rams in a common association (The American Rambouillet Sheep Breeders' Association), some corrective measures need to be taken. Preferably, this would be done without lowering current standards that have been in effect for many years. One suggested solution for future ram tests would be as follows. First, both testing agencies would measure AFD and CV of side, britch and whole fleeces. The current certification standards based on side and britch AFD measurements would be retained. However, the TAES index equation would be modified to match the UW equation in which AFD and CV of whole fleeces are used instead of AFD of side samples and AFD differences (britch minus side). In general, measures of fiber diameter variability are expected to become more important to breeders and processors since measurement methods have become more efficient.

Figure 1. Side sample fiber diameter (SAFD) versus pre-test core average fiber diameter (PTCAFD).

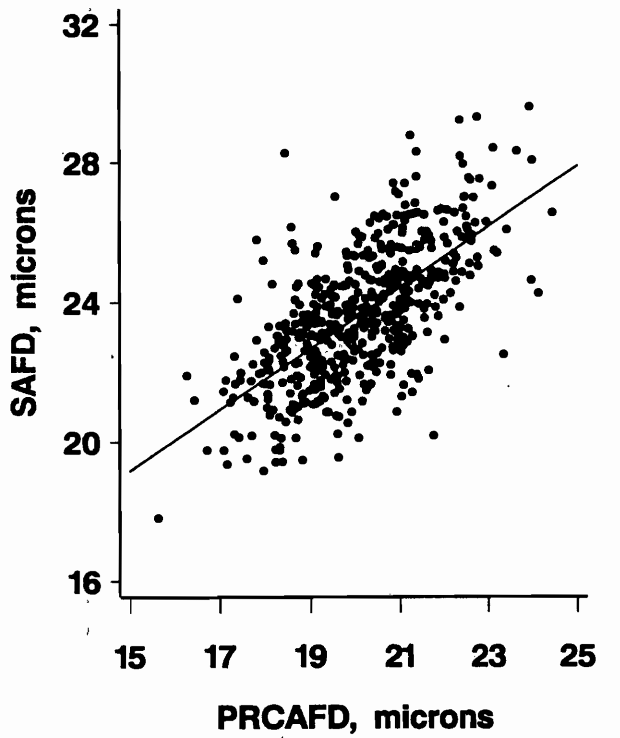

Figure 2. Side sample fiber diameter (SAFD) versus post-test core average fiber diameter (POCAFD).

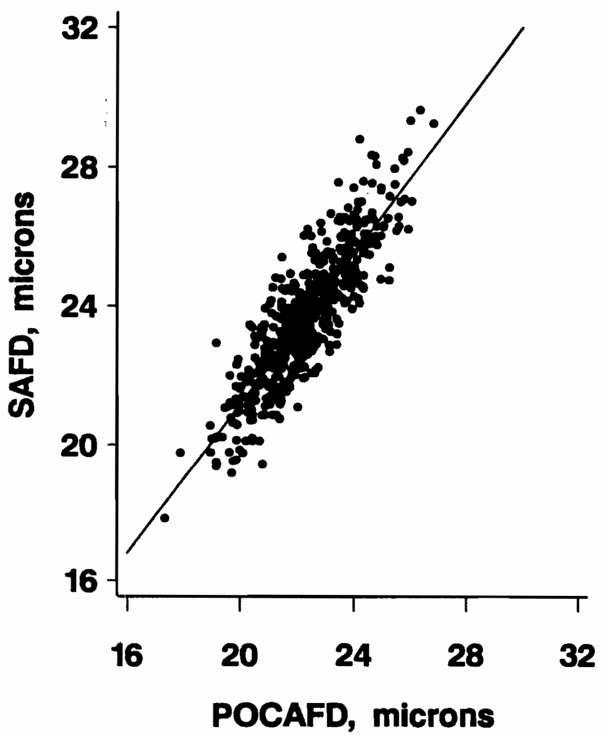

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Figure 3. Britch minus side average fiber (B – S AFD) versus coefficient of variation of fiber diameter for whole fleece (POCCV).