Selection of Woven Wire Screens for Separating *Poa pratensis* L. and *Poa trivialis* L. Seed[1]

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ABSTRACT

Woven wire screens for separating Kentucky bluegrass (*Poa pratensis* L.) from rough bluegrass (*Poa trivialis* L.) seed were tested and the most effective square and rectangular-opening screens identified. The most effective separations overall, where the largest percentage of the crop species was saved and the highest amount of contaminant was removed, resulted from screening with a square 30 x 30 woven wire screen or a rectangular 6 x 28 woven wire screen. However these results varied for some of the mixtures tested. Cultivars of these species differed in ease of separation, because of seed size differences within each species.

Additional index words: **Kentucky bluegrass, rough bluegrass, seed cleaning, seed size, cultivars.**

INTRODUCTION

Kentucky bluegrass (*Poa pratensis* L.) and rough bluegrass (*Poa trivialis* L.) are grown as perennial seed crops in regions of Oregon, Washington and Idaho, USA. There are approximately 160 registered cultivars of Kentucky bluegrass (Kbg) in seed certification programmes. Fewer than twenty cultivars of rough bluegrass (Rbg) exist, due to its more recent development in modern plant breeding schemes. Both species are widely used in golf courses and lawns. However, mixtures or blends of seeds of these two species are not used, because of their dissimilar growth habit and colour. Further, Kbg seed produced for turf production must usually be free of any contamination by Rbg. Unintentional mixing of Kbg and Rbg can occur as a result of field contamination, contamination from harvest equipment, transport, or seed conditioning equipment. Both species have become established in non-cultivated areas, such as irrigation and drainage canals and roadways, increasing the possibility of accidental mixing. Even a small percentage of mixing can be the grounds for reduced seed lot value, rejection, or possible litigation.

The seeds of these species are small and similar in size, roughly 2.54 mm long by 0.64 mm in width and thickness. However small differences exist in size between species. Even smaller differences exist among some cultivars within each species, and growers often identify bluegrass cultivars as large- or small-seeded. As a result, careful selection of screens for seed conditioning may help reduce the occurrence of non-crop bluegrass species in seed lots, improve their purity and value, and reduce discarded crop seed.

Usually during seed screening processes, two fractions, a crop fraction and a discard fraction, are created from the original material. Crop seed in the resulting discard fraction or weed seed in the crop fraction have been misplaced or misclassified by the seed conditioning procedure. Seed lots are usually screened several times between harvest and packaging, depending on the quantity, size and shape of foreign material present and the desired purity of the final product. Screens are used to remove particles both larger and smaller than the crop seed. Separation of seed lots based on differences in width is accomplished by screens with square or round openings. Separation based on differences in thickness is accomplished by screens with rectangular, oblong or slotted openings. Material for seed screens is generally either perforated metal sheet or woven wire screen. For many seed growers, woven wire is the preferred material because it is available in a wide range of smaller sizes. Woven wire has a greater open area than similarly-sized perforated metal screens, and its rougher surface agitates the seed during conditioning, encouraging the separation. Woven wire screens are designated in number of openings per inch[5] in two directions. A 6 x 24 woven wire screen would have 6 openings per inch in the length direction and 24 openings per inch in the width direction. In this research, an attempt was made to identify woven wire screens that would aid in producing seed lots with reduced levels of non-crop bluegrass.

Many aspects of conditioning seed with screens have been reported. Batel (1960) and Harmond, Brandenburg and Klein (1968) described the use of air-screen machines, screen numbering systems, and methods for selecting screens. The effect of screening duration on the size distribution of the product has been studied (Feller and

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[5] *Although SI units are usually used in this journal, seed screens are internationally cited as openings per inch (Editor).*

Foux, 1976). Particle size relative to perforation size was found to be a significant factor affecting the rate at which seed passed through screens. The effect of screen motion on the passage of particles through screen openings has been investigated (Feller and Foux, 1975; Minaev and Regge, 1983). Screen acceleration and amplitude were found to have the greatest effect on particle passage when duration was not considered. Screen inclinations and linkage angles, common to screening machines, were found to have no significant effect. The effects of particle size on clogging rate of screens (Feller, 1977), particle orientation, and opening size on passage rate (Harrison and Blecha, 1983) were also studied. Feller and Pasternak (1980) described a method for evaluating screening operations using deviations. Churchill, Bilsland and Cooper (1992) found that the precision of measuring seeds and screens using a machine vision system was better than measurement microscopically by hand. Seed-screening machine manufacturers provide general recommendations for screen-opening sizes and shapes for common crops. However, this information does not recommend screens for removing specific contaminants from crops.

MATERIALS AND METHODS

Five cultivars of Kbg (Merit, Rugby, Geronimo, Georgetown, Gnome) and three cultivars of Rbg (Laser, Sabre, Cypress) were acquired from growers in the region. These lots had undergone normal seed conditioning procedures including screening and debearding. Random samples of each cultivar were taken for microscopic width and thickness measurement.

Selection of woven wire screens for these separations included a range between those that would allow all seed to pass through openings to those where all seed would be entirely held on the screen top surface. Woven wire screens with square opening widths ranging from 0.018 inch to 0.042 inch and screens with rectangular opening widths ranging from 0.015 inch to 0.035 inch, were selected. These included 11 screens with square openings (38, 36, 34, 32, 30, 28, 26, 24, 22, 20 and 18 openings per inch) and 13 screens with rectangular openings (6 openings per inch in the length direction and the following openings per inch in the width direction: 40, 38, 36, 34, 32, 30, 28, 26, 25, 24, 23, 22 and 20). Opening sizes of all woven wire screens used in this research were microscopically measured to the nearest 0.001 of an inch.

Random samples of approximately 70 g of each cultivar were taken using a Boerner divider. The samples were individually placed on each screen and shaken using a screen shaker for 1 minute at 10 hz and 8.26 mm amplitude. These settings were selected to simulate treatment in a commercial seed cleaner. The weights of the sample fraction held on the screen top surface and the fraction passing through each screen were recorded for each cultivar, and each screen opening type and size.

Finally, to compare the predicted results to results that growers might expect, blends of two Kbg and two Rbg cultivars were created. A large-seeded Kbg, cv. Gnome, was mixed with a large-seeded Rbg, cv. Sabre, and with a small-seeded Rbg, cv. Cypress. A small-seeded Kbg, cv. Rugby, was mixed with a large-seeded Rbg, cv. Sabre, and with a small-seeded Rbg, cv. Cypress. In these four mixtures, Kbg was the intended crop, and comprised 99% of the mixtures by weight. For the second set of mixtures, a large-seeded Rbg, cv. Sabre, was mixed with a large-seeded Kbg, cv. Gnome, and with a small-seeded Kbg, cv. Rugby. A small-seeded Rbg, cv. Cypress, was mixed with a large-seeded Kbg, cv. Gnome, and with a small-seeded Kbg, cv. Rugby. In these four mixtures Rgb was the intended crop, and comprised 99% of the mixtures by weight. Three replicated separations of each of the eight mixtures were made using a 6 x 28 screen and a 30 x 30 screen, resulting in a total of 48 tests. The resulting crop fractions were submitted for seed purity testing by a certified seed analyst.

RESULTS AND DISCUSSION

Rough bluegrass cultivars were smaller than Kbg cultivars in both width and thickness (Fig. 1). Some size variation among cultivars also existed within each species

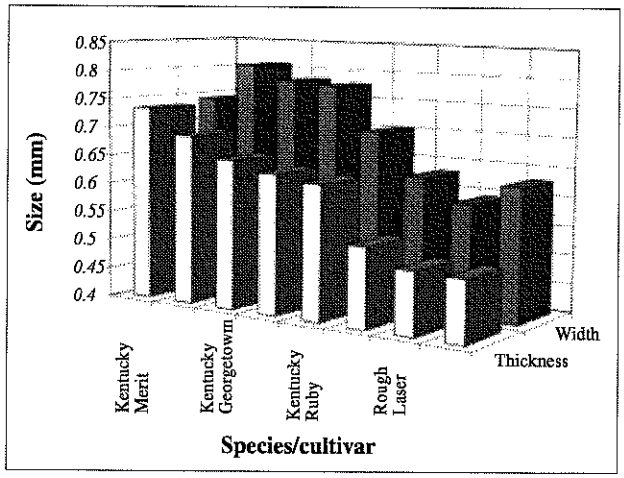

Fig 1. Average seed width and thickness of cultivars of Kentucky and rough blue grass.

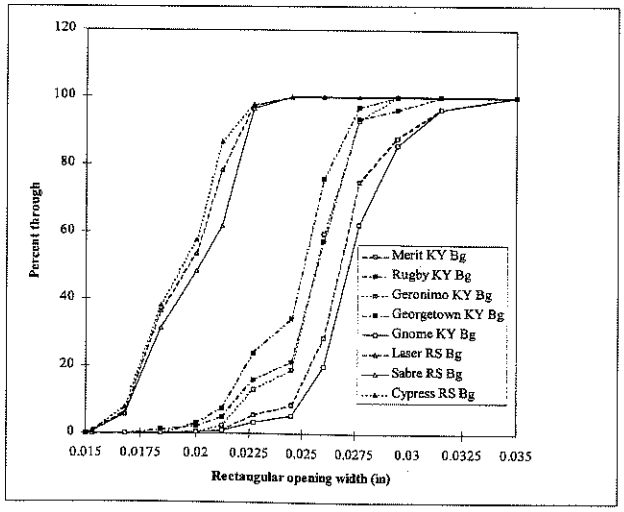

Fig 2. Percentage of seed by weight passing through screens with rectangular openings in thousandths of inches.

Table 1. Openings per inch compared to actual opening width in inches.

Openings/in	Rectangular opening width (in)	Square opening width (in)
40	0.0150	N/A
38	0.0153	0.0183
36	0.0168	0.0198
34	0.0184	0.0214
32	0.0212	0.0223
30	0.0200	0.0253
28	0.0227	0.0257
26	0.0245	0.0275
25	0.0260	N/A
24	0.0277	0.0307
23	0.0295	N/A
22	0.0315	0.0335
20	0.0350	0.0370
18	N/A	0.0426

The percentage by weight of each cultivar passing through screens with rectangular openings is shown in Fig. 2, where the x-axis represents the actual opening size in thousandths of inches. Figure 3 shows the percentage by weight of each cultivar passing through each screen with rectangular openings where the x-axis shows openings per inch. The apparent disparity in the data is the result of differences in screen wire diameter, creating opening sizes that are not proportional to openings per inch. Table 1 shows results of microscopically measured rectangular and square opening widths compared to openings per inch. As suggested by the weight data, the woven wire screen with 30 rectangular openings per inch has smaller openings than one with 32 openings per inch.

The percentage by weight of each cultivar passing through screens with square openings is shown in Fig. 4 where the x-axis represents the actual opening size in thousandths of inches. Figure 5 shows the percentage by weight of each cultivar passing through each screen with

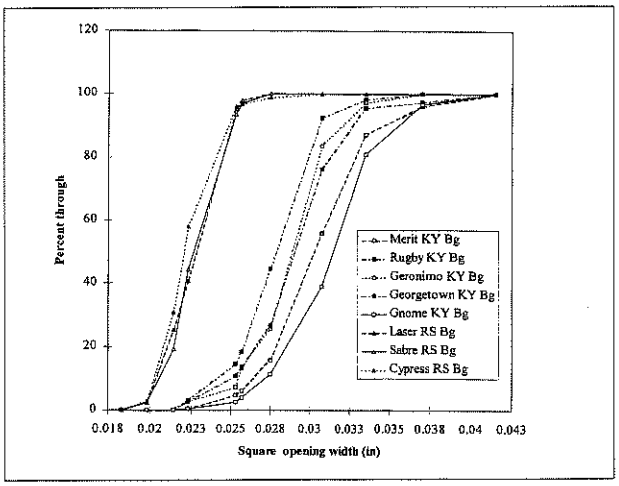

Fig. 4. Percentage of seed by weight passing through woven wire screens with square openings in thousandths of inches.

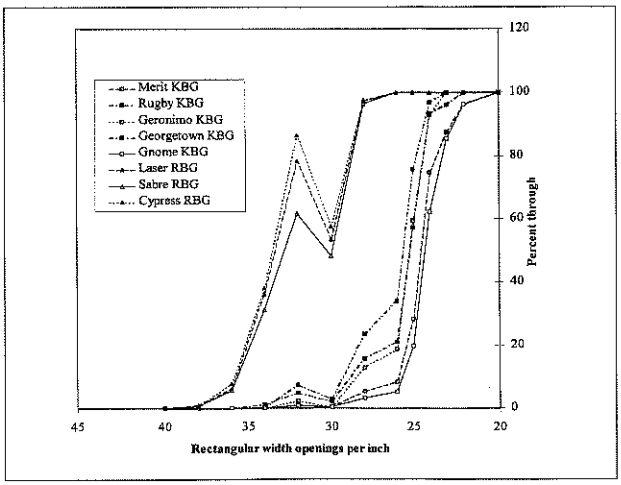

Fig. 3. Percentage of seed by weight passing through woven wire screens with rectangular openings in openings per inch.

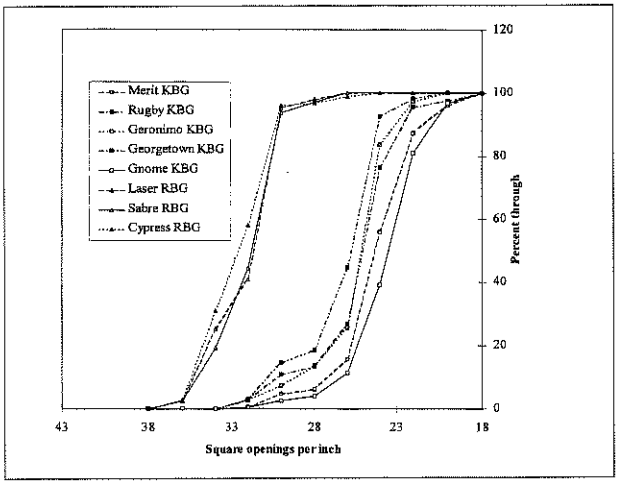

Fig. 5. Percentage of seed by weight passing through screens with square openings in openings per inch.

the x-axis in openings per inch. These data also show that the sizes of openings between these screens are not of equal increments. This suggests that while woven wire screens are available to separate Kbg and Rbg, seed cleaner operators should know the opening sizes of their woven wire screens as well as the number of openings per inch.

Evaluating these separations to determine the screen best suited for a separation can be subjective to the

Table 2. Fraction of each cultivar held by rectangular and square opening woven wire screens.

	Rectangular width openings per inch												
Cultivar	**40**	**38**	**36**	**34**	**32**	**30**	**28**	**26**	**25**	**24**	**23**	**22**	**20**
Merit KBG	1.00	1.00	1.00	1.00	0.99	1.00	0.95	0.92	0.72	0.25	0.12	0.04	0.00
Rugby KBG	1.00	1.00	1.00	1.00	0.93	0.97	0.76	0.66	0.24	0.03	0.00	0.00	0.00
Geronimo KBG	1.00	1.00	1.00	1.00	0.98	1.00	0.87	0.81	0.41	0.07	0.00	0.00	0.00
Georgeywn KBG	1.00	1.00	1.00	0.99	0.95	0.98	0.84	0.79	0.43	0.07	0.04	0.00	0.00
Gnome KBG	1.00	1.00	1.00	1.00	0.99	1.00	0.97	0.95	0.80	0.38	0.15	0.04	0.00
Laser RBG	1.00	0.99	0.94	0.64	0.22	0.46	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Sabre RBG	1.00	0.99	0.94	0.69	0.38	0.52	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Cypress RBG	1.00	0.99	0.92	0.62	0.14	0.42	0.02	0.00	0.00	0.00	0.00	0.00	0.00

	Square openings per inch										
Cultivar	**38**	**36**	**34**	**32**	**30**	**28**	**26**	**24**	**22**	**20**	**18**
Merit KBG	1.00	1.00	1.00	1.00	0.95	0.94	0.84	0.44	0.13	0.04	0.00
Rugby KBG	1.00	1.00	1.00	0.97	0.86	0.82	0.55	0.08	0.02	0.00	0.00
Geronimo KBG	1.00	1.00	1.00	0.97	0.93	0.86	0.74	0.17	0.03	0.00	0.00
Georgetwn KBG	1.00	1.00	1.00	0.98	0.89	0.87	0.73	0.24	0.05	0.02	0.00
Gnome KBG	1.00	1.00	1.00	1.00	0.97	0.96	0.89	0.61	0.19	0.03	0.00
Laser RBG	1.00	0.97	0.75	0.59	0.05	0.02	0.00	0.00	0.00	0.00	0.00
Sabre RBG	1.00	0.98	0.81	0.56	0.06	0.03	0.00	0.00	0.00	0.00	0.00
Cypress RBG	1.00	0.97	0.69	0.42	0.04	0.03	0.01	0.00	0.00	0.00	0.00

Table 3. Fraction of each cultivar passing through rectangular and square opening woven wire screens.

	Rectangular width openings per inch												
Cultivar	**40**	**38**	**36**	**34**	**32**	**30**	**28**	**26**	**25**	**24**	**23**	**22**	**20**
Merit KBG	0.00	0.00	0.00	0.00	0.01	0.00	0.05	0.08	0.28	0.75	0.88	0.96	1.00
Rugby KBG	0.00	0.00	0.00	0.00	0.07	0.03	0.24	0.34	0.76	0.97	1.00	1.00	1.00
Geronimo KBG	0.00	0.00	0.00	0.00	0.02	0.00	0.13	0.19	0.59	0.93	1.00	1.00	1.00
Georgetwn KBG	0.00	0.00	0.00	0.01	0.05	0.02	0.16	0.21	0.57	0.93	0.96	1.00	1.00
Gnome KBG	0.00	0.00	0.00	0.00	0.01	0.00	0.03	0.05	0.20	0.62	0.85	0.96	1.00
Laser RBG	0.00	0.01	0.06	0.36	0.78	0.54	0.98	1.00	1.00	1.00	1.00	1.00	1.00
Sabre RBG	0.00	0.01	0.06	0.31	0.62	0.48	0.96	1.00	1.00	1.00	1.00	1.00	1.00
Cypress RBG	0.00	0.01	0.08	0.38	0.86	0.58	0.98	1.00	1.00	1.00	1.00	1.00	1.00

	Square openings per inch										
Cultivar	**38**	**36**	**34**	**32**	**30**	**28**	**26**	**24**	**22**	**20**	**18**
Merit KBG	0.00	0.00	0.00	0.00	0.05	0.06	0.16	0.56	0.87	0.96	1.00
Rugby KBG	0.00	0.00	0.00	0.03	0.14	0.18	0.45	0.92	0.98	1.00	1.00
Geronimo KBG	0.00	0.00	0.00	0.03	0.07	0.14	0.26	0.83	0.97	1.00	1.00
Georgetwn KBG	0.00	0.00	0.00	0.02	0.11	0.13	0.27	0.76	0.95	0.98	1.00
Gnome KBG	0.00	0.00	0.00	0.00	0.03	0.04	0.11	0.39	0.81	0.97	1.00
Laser RBG	0.00	0.03	0.25	0.41	0.95	0.98	1.00	1.00	1.00	1.00	1.00
Sabre RBG	0.00	0.02	0.19	0.44	0.94	0.97	1.00	1.00	1.00	1.00	1.00
Cypress RBG	0.00	0.03	0.31	0.58	0.96	0.97	0.99	1.00	1.00	1.00	1.00

requirements of the seed lot. If a seed lot must be completely free of non-crop, Kbg or Rbg, then a screen must be selected accordingly. For example, a rectangular 6 x 28 woven wire screen would pass nearly 100% of the Rbg from the Kbg cultivars. However, the amount of crop mixed with Rbg in the through screen fraction would vary somewhat for each Kbg cultivar. Approximately 24% of the original amount of cv. Rugby, 16% of cv. Georgetown, 13% of cv. Geronimo, 5% of cv. Merit, and 3% of cv. Gnome would be discarded in the through fraction using a 6 x 28 woven wire screen. These differences support the size data (Fig. 1), and the concept that particles with greater size differences are most easily separated. Further, if a margin of safety is suggested because of contractual or other needs, one screen size larger would be recommended when the crop is Kbg. Misclassification of crop seed would increase accordingly.

A less subjective method of selecting screen sizes for crop Kbg is to calculate the product of the fraction of Rbg through the screen and the fraction of Kbg held by the same screen (Tables 2 and 3). Separation quality is represented by the following:

Separation quality = (fraction of contaminant removed) (fraction of crop saved).

Higher values from this calculation would indicate better separations. A value of 1.0 would indicate a perfect separation where all Rbg passed through the screen and all Kbg was held above the screen. This method of evaluating separations applies equal importance to removing contaminants and to saving crop seed. For example, it is apparent that those screens on either extreme are ineffective in these separations because they place all of the crop and contaminant together in a held or through fraction (Figs. 2-5). However, it is less apparent whether using a 6 x 28 woven wire screen results in a better separation than using a 30 x 30 woven wire screen. After calculating the product of the fraction of Geronimo Kbg held by these screens (0.87 rectangular, 0.93 square) by the fraction of Sabre Rbg through the screen (0.96 rectangular, 0.94 square), results of 0.84 for the rectangular-opening and 0.86 for the square-opening screens are achieved. The woven wire screen with 30 square openings per inch should give slightly higher separation quality for the mixture. Predictions for the optimum screen sizes for Rbg can be made similarly. Figure 6 shows the average predicted separation quality for screens with different numbers of openings per inch calculated from Tables 2 and 3 for the fifteen possible mixtures of Kbg and Rbg used in this research. This figure also shows the effect of non uniform wire size in the data point representing the screen with 30 rectangular openings per inch.

Most often, producers of grass seed know only the name of the crop cultivar that they are producing, and usually not the cultivar name of the contaminant. Depending on the purity requirements, screens that removed all of the largest cultivar of Rbg (cv. Sabre) from Kbg and all of the smallest Kbg (cv. Rugby) from Rbg may be safe choices. When the crop was Kbg, these would screen with either a 6 x 26 or 26 x 26 woven wire screen. When the crop was Rbg these would screen either with a 6 x 34 or 34 x 34 woven wire screen. However, attaining pure Rbg using these screens may result in misclassification of up to 70% of the crop.

Another consideration in selecting screens for these crops is whether the cultivar is large or small seeded. Small seeded Kentucky bluegrasses are most difficult to separate from Rbg, and similarly large seeded rough bluegrasses are most difficult to separate from Kbg. Depending on the severity of the problem, growers might consider intentionally growing one of the large seeded Kbg or small seeded Rbg cultivars to encourage good separation.

Figure 7 shows the percentage of contamination remaining after screening eight mixtures of Kbg and Rbg. The percentage of contamination remaining is a measure of the difficulty of separation. As expected, for both screens cv. Rugby, the small-seeded Kbg, was most difficult to separate from the rough bluegrasses while cv. Gnome, the large-seeded Kbg, was most easily separated. Similarly, cv. Cypress, the small seeded Rbg, was most easily separated from Kentucky bluegrasses while cv. Sabre, the large seeded Rbg, was most difficult to separate.

Overall, the more predictable results were achieved

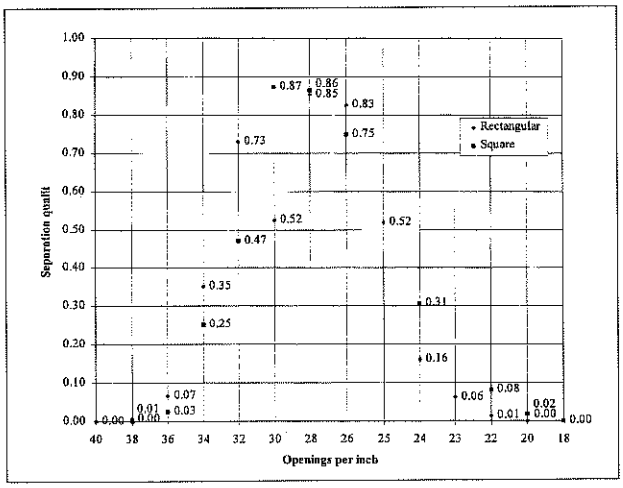

Fig. 6. Average predicted separation quality for screens with different numbers of openings per inch for fifteen possible mixtures of Kentucky bluegrass and rough bluegrass.

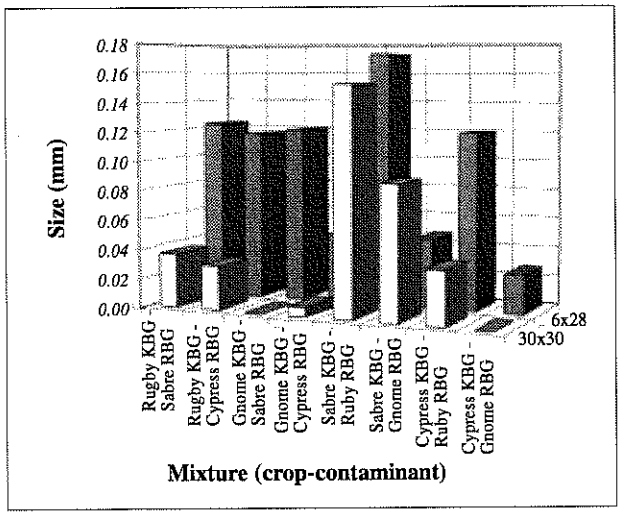

Fig. 7. Average percentage of contamination remaining after screening mixtures of Kentucky and rough blue grasses. The first cultivar listed is the crop.

using the 6 x 28 screen, a thickness separator, supporting the measurement data. This suggests that the thickness differences were greater between these two species than were the width differences. This screen reduced contamination from the original 1.00% to 0.00% in two of the eight cases. For all of the Kentucky bluegrasses tested, the 6 x 28 screen left an average of 0.02% Rbg, a 98% reduction, and saved an average of 78% of the crop. For all rough bluegrasses, the 6 x 28 screen left an average of 0.07% Kbg, a 93% reduction, and saved 94% of the crop. For all Kentucky bluegrasses, the 30 x 30 screen left an average of 0.10% Rbg, a 90% reduction, and saved 85% of the crop. For all rough bluegrasses, the 30 x 30 screen left an average of 0.09% Kbg, a 91% reduction, and saved 92% of the crop.

SUMMARY AND CONCLUSIONS

The Kbg and Rbg cultivars in this study could be effectively separated with rectangular- and square-opening woven wire screens. Best overall results were obtained with either a 30 x 30 or a 6 x 28 woven wire screen.

Based on seed size differences, some cultivars were more easily separated than others. Kentucky bluegrass cv. Rugby was most difficult to separate while cv. Gnome was separated most readily from Rbg cultivars. Rough bluegrass cv. Sabre was most difficult while cv. Cypress separated most readily from Kbg cultivars.

Obtaining pure Kbg seed may result in between 7% and 35% misclassified crop seed. Obtaining pure Rbg seed may result in 60% to 70% misclassified crop seed.

Seed cleaner operators should be aware of both numbers of wires per inch and actual opening size, since wire diameter is not always consistent. Microscopic measurement of woven wire screen opening size is one possible solution.

If Rbg contamination continues to be problematic, Kbg growers may be able to improve seed lot purity by growing large-seeded cultivars.

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