

# High seed retention of Indian ricegrass PI 478833

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## Abstract

Reduction of Indian ricegrass [*Oryzopsis hymenoides* (Roem. and Schult.) Ricker] seed shattering losses is of interest because it would result in more economical seed harvest. PI 478833, a genotype with glumes closely surrounding the seed, was compared with 'Paloma' for glume pair angle and seed retention parameters. Our objective was to determine its suitability as a source of seed shattering resistance for genetic transfer to an Indian ricegrass variety. Regrowth from a 19 June 1989 clipping of 'Paloma' and PI 478833 with and without supplemental irrigation was evaluated in late July. Irrigation did not affect glume pair angle or percentage intact seed (number of seeds/number of mature florets). Though Paloma and PI 478833 glume pair angles averaged 66° and 44°, respectively, percentage intact seed was 13% higher for Paloma than PI 478833 because Paloma's more indeterminate flowering pattern allowed it to replace its shattered florets more quickly than PI 478833. In a second experiment we observed individual florets of Paloma and PI 478833 for 7 weeks starting 5 September 1989. Floret opening occurred mostly during daylight hours and on warm days. Shattering events occurred when a storm followed a period of floret opening. Duration of seed retention from glume opening to shattering averaged 91% longer for PI 478833 than Paloma. After 7 weeks 83 and 35% of Paloma and PI 478833 florets had shattered, respectively. In a third experiment seed retention index (seed yield/forage dry weight) on 15 September 1989 was 0.45, 0.19, and 0.11 for PI 478833, 'Nezpar', and Paloma, respectively. PI 478833's acute glume pair angle and resultant increased seed retention make it a valuable source of shattering resistance for introduction into bred Indian ricegrass varieties.

**Key Words:** genotypic variation, Nezpar, *Oryzopsis hymenoides*, Paloma, seed production, seed shattering

Seed shattering is a major problem in Indian ricegrass [*Oryzopsis hymenoides* (Roem. and Schult.) Ricker] seed production (Jones 1990). Reduction of seed shattering losses would have a favorable economic impact on seed production, probably benefiting both the producer and consumer. A high degree of floral indeterminacy in Indian ricegrass means seeds typically begin to shatter while later panicles continue to bloom. Indian ricegrass is primarily self-pollinated (Jones and Nielson 1989) and seeds mature quickly after panicle emergence. Mature seeds abscise along an abscission layer between the floret and the rachilla (Whalley et al. 1990). The glumes, appendages that subtend the seed, open and permit the seed to shatter. Glumes subtending unfilled seeds open normally, but the seeds do not abscise. Thus, casual observation can give the false impression of high seed retention, particularly in arid environments where seed fill percentage is low

(Jones 1990).

Whalley et al. (1990) found that PI 478833 (Yellowstone Co., Mont.) exhibits a more acute angle between the opened glumes (glume pair angle) than 'Paloma'. This acute glume pair angle may allow the plant to hold the seed longer, thereby reducing seed shattering losses. Comparison of bagged and unbagged treatments suggested higher seed retention in PI 478833 than Paloma, but seed shattering was not measured directly. The objectives of this study were to measure glume pair angles and percentage intact seed in Paloma and PI 478833 with and without supplemental irrigation, to determine the circumstances under which shattering occurs, to quantify rate of floret opening and seed shattering and relative duration of seed retention in these 2 genotypes, and to compare seed retention index of PI 478833 with Paloma and 'Nezpar' in the fall after most seed has shattered.

## Materials and Methods

### Glume Pair Angle and Percentage Intact Seed with and without Irrigation-Experiment 1

Seedlings were transplanted 18 August 1987 from a greenhouse to a Millville silt loam (coarse-silty, carbonatic, mesic Typic Haploxerolls) in North Logan, Utah. Four 20-plant replications of Paloma and PI 478833 were arranged on 1-m centers in a split-plot design with genotypes as whole plots and irrigation treatments as split plots. Test plants were surrounded by a border of PI 478833. On 19 June 1989 the plants were clipped at 15 cm to remove spring growth. The experiment was conducted on subsequent regrowth under summer conditions, permitting greater impact of the application of irrigation water.

Circular irrigation basins were dug around each plant and lined with sand to prevent moisture loss from soil cracking. A gravity-fed polyvinylchloride irrigation system directed water from a nearby canal to all basins in each irrigated 10-plant split plot 3 times weekly from 19 June to 28 July. Plants were irrigated to field capacity.

At the end of the irrigation period, glume pair angle was measured on 5 shattered and 5 open but unshattered florets from all plants, as described by Whalley et al. (1990). Panicles were harvested and counts were made of numbers of (1) mature florets, those opened and shattered or with a filled unshattered seed; (2) immature florets, including those aborted and deformed; and (3) filled seeds. Percentage intact seeds was calculated as (filled seeds/mature florets) × 100, and an arcsine transformation was applied to these data before analysis. Data are presented as untransformed means.

### Duration of Seed Retention-Experiment 2

About 6 weeks after the late-July clipping of Experiment 1, 5 unopened florets were selected from regrowth of 20 unirrigated plants of each genotype (Experiment 1). Florets were marked 5 September and their status (unopened, opened, or shattered) was

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monitored at 0800, 1000, and 2000 hours for 10 days, daily for an additional 19 days, and weekly for an additional 3 weeks. Panicles without marked florets were removed at the beginning of the experiment to increase seed set on remaining panicles. On day 50 the experiment was terminated, unshattered florets were checked for seed fill, and 11 seedless florets (of the original 200) were deleted from the data set. Duration of seed retention was calculated as the average number of days between glume opening and seed shattering. Paloma and PI 478833 were compared by a *t* test, using independent variance estimates for the 2 genotypes.

### Late-Season Seed Retention Index-Experiment 3

Transplants of Paloma, Nezpar, and PI 478833 were established 15 October 1986 on a Nibley silty clay loam (fine, mixed, mesic Aquic Argiustolls) in Providence, Utah. Four replications of each genotype, each with 10 plants on 0.5-m centers, were surrounded by a Paloma border. Poor establishment limited measurements to 29, 21, and 30 plants of Paloma, Nezpar, and PI 478833, respectively. In 1989 seed was permitted to shatter until 15 September when individual plants were harvested at a 15-cm clipping height. Plant dry weight, seed number, and seed yield were measured on a per-plant basis. Forage dry weight was calculated by subtracting seed yield from plant dry weight. Seed retention index of a plant was calculated as seed yield/forage dry weight. Seed weight of a plant was calculated as seed yield/seed number.

Least-squares means (Freund and Littell 1981) were estimated to eliminate error caused by the unbalanced data. Differences between least-squares means were tested using the Bayes L.S.D. (*k* ratio = 100) (Smith 1978). The replication  $\times$  entry error term was used to construct the test statistic.

## Results and Discussion

### Experiment 1

Paloma and PI 478833 glume pair angles averaged 66° and 44°, respectively, with genotypes ( $P < 0.01$ ) accounting for 94% of the nonerror variation in the experiment. No differences ( $P < 0.10$ ) were found for irrigation, genotype  $\times$  irrigation, or shattered vs. unshattered florets. Glume pair angles were about 17° greater than those of Whalley et al. (1990), but the difference between genotypes was similar.

Despite Paloma's 50% larger glume pair angle, its percentage intact seeds was 13% greater than PI 478833's (Table 1). We attribute this to an experimental artifact, namely the greater capacity of Paloma to regrow and to flower in this regrowth, as reported earlier (Whalley et al. 1990) and supported by our mature and

**Table 1. Percentage intact seeds and numbers of mature and immature florets per plant for Paloma and PI 478833 regrowth with and without irrigation at North Logan, Utah on 28 July 1989.**

| Genotype               | Intact seeds | Mature florets                        | Immature florets |
|------------------------|--------------|---------------------------------------|------------------|
|                        | (%)          | (No./plant)<br>Irrigated <sup>1</sup> | (No./plant)      |
| Paloma                 | 67.5         | 435                                   | 1840             |
| PI 478833              | 53.4         | 223**                                 | 385**            |
| L.S.D. <sub>0.05</sub> | 19.6         | 151                                   | 421              |
|                        |              | Unirrigated <sup>1</sup>              |                  |
| Paloma                 | 60.8         | 452                                   | 1173             |
| PI 478833              | 48.2*        | 187*                                  | 285*             |
| L.S.D. <sub>0.05</sub> | 8.7          | 261                                   | 489              |

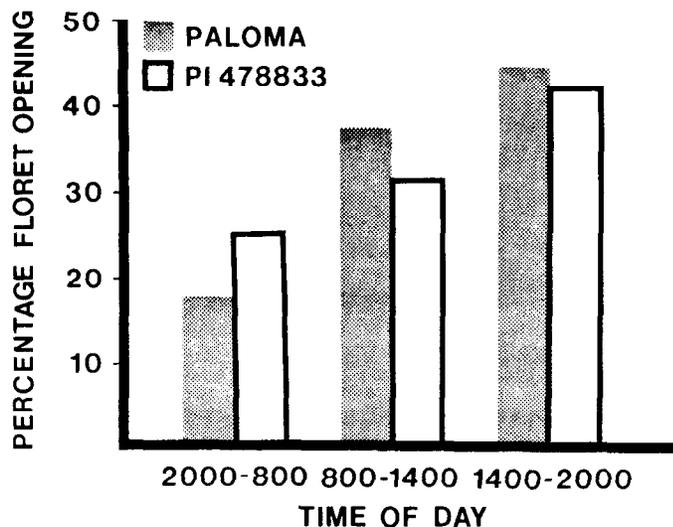
\*,\*\*Significantly different at  $P < 0.05$  and  $0.01$ , respectively.

<sup>1</sup>Genotype  $\times$  irrigation treatment interaction nonsignificant ( $P < 0.10$ ) for percentage intact seeds and numbers of mature florets and significant ( $P < 0.05$ ) for numbers of immature florets.

immature floret data. This especially indeterminate flowering pattern of Paloma permitted recruitment of large numbers of immature florets to replace shattered florets. PI 478833 had much fewer of these "reinforcements", so shattered seed could not be easily replaced. Irrigation did not increase ( $P > 0.10$ ) numbers of mature florets and its increase of percentage intact seeds was nonsignificant ( $P = 0.12$ ). But irrigation did increase numbers of immature florets 57 and 35% for Paloma and PI 478833, respectively (genotype  $\times$  irrigation interaction significant at  $P < 0.05$ ), indicative of the floret recruitment advantage of Paloma. This floret recruitment advantage would be expected to have lesser importance under normal seed production conditions because initial growth is harvested instead of regrowth.

### Experiment 2

Floret opening was greater during daylight than nighttime hours (Fig. 1). Floret opening also tended to be greater on clear warm



**Fig. 1. Time of day of floret opening of Paloma and PI 478833 from 5 to 15 September 1989.**

days than on overcast cool days. By day 29 the percentage of florets with opened glumes was 98 and 61% for Paloma and PI 478833, respectively (Fig. 2). Shattering curves of the 2 genotypes were of similar shapes, but Paloma's rate of shattering was over twice as great as PI 478833's (Fig. 2). By day 29 83% of the mature Paloma seed had shattered, of a possible maximum of 98% opened florets, compared to 35 of a possible 61% for PI 478833. Floret opening and seed shattering were minimal after day 29. Average duration of seed retention was 91% longer for PI 478833 (6.7 days) than Paloma (3.5 days) ( $P < 0.01$ ). In contrast to Paloma, many of the PI 478833 florets produced a filled seed without ever opening their glumes.

A disproportionate amount of shattering occurred as a result of discrete shattering "events". Atmospheric disturbance can result in shattering if glumes enclosing a filled seed are open. The first major shattering event was triggered by a hailstorm on day 6. But while 12 of 20 open unshattered Paloma florets shattered, only 3 of 15 such florets of PI 478833 did so. A severe windstorm on day 13 caused the second major shattering event, abetted by a high degree of floret opening on day 8. Twenty-seven of 39 open unshattered Paloma florets shattered, while only 16 of 38 such florets of PI 478833 did so. After this storm shattering continued, but at a much slower rate, especially in PI 478833. In both genotypes this shattering reduction appeared correlated with a decreased rate of floret opening, more pronounced in PI 478833 than Paloma.

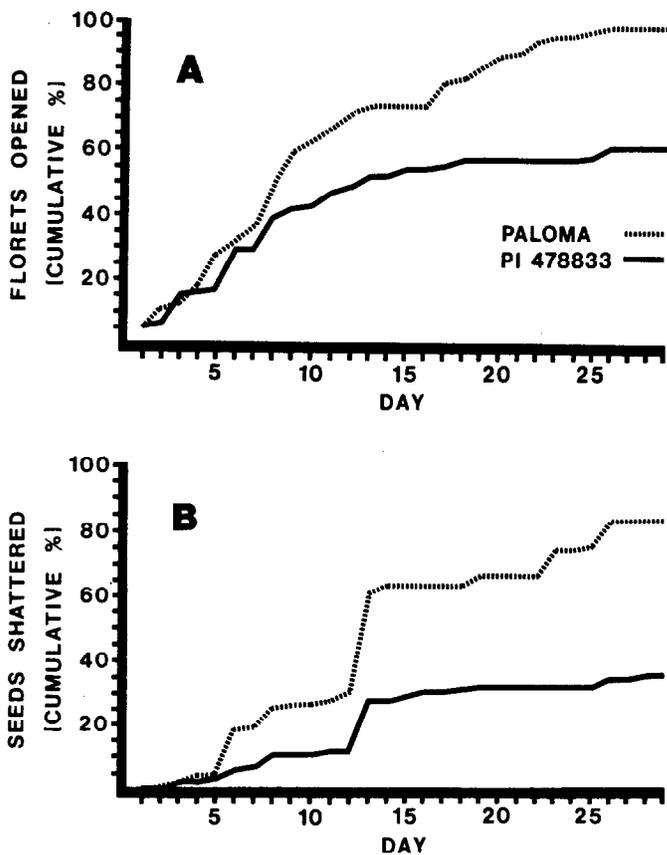


Fig. 2. Daily cumulative percentage of a) florets opened and b) seeds shattered of Paloma and PI 478833 beginning 5 September 1989.

Table 2. Least-squares means of forage dry weight (g/plant), seed yield (g/plant), seed retention index (g seed yield/g forage dry weight), seed number, and seed weight (mg/seed) of PI 478833, Nezpar, and Paloma at Providence, Utah 15 September 1989.

| Genotype  | Forage dry weight (g/plant) | Seed yield (g/plant) | Seed retention index (g SY/g FDW) | Seed number (no./plant) | Seed weight (mg/seed) |
|-----------|-----------------------------|----------------------|-----------------------------------|-------------------------|-----------------------|
| PI 478833 | 16.3 a                      | 7.0 a                | 0.307 a                           | 1932 a                  | 3.64 b                |
| Nezpar    | 11.3 a                      | 1.9 b                | 0.154 b                           | 602 b                   | 2.89 c                |
| Paloma    | 12.7 a                      | 1.6 b                | 0.096 c                           | 331 b                   | 4.40 a                |
| Bayes     |                             |                      |                                   |                         |                       |
| L.S.D.    | ns                          | 1.7                  | 0.041                             | 422                     | 0.45                  |

Means in a column followed by different letters are significantly different by the Bayes L.S.D. (k ratio = 100).

### Experiment 3

Seed weight of Paloma was 52% greater than Nezpar, with PI 478833 intermediate (Table 2). Nezpar is comprised of roughly equal proportions of "big black" (globose) and "small black" (elongate) seed polymorphisms, but Paloma seed is predominantly globose (Young and Evans 1984). PI 478833 seed has the globose shape of Paloma but is considerably smaller.

Instead of the tedious direct counting procedure employed in Experiment 1, in Experiment 3 the less labor-intensive indirect method of seed retention index was used to make inferences with regard to seed shattering. If seed production is roughly proportional to dry-matter production, then seed retention index after extensive shattering is a good estimate of relative seed retention. On 15 September seed retention index of PI 478833 was about 2.4 and 4.1 times (k ratio = 100) that of Nezpar and Paloma, respectively.

### Conclusions

Indian ricegrass exhibits seed production and dispersal strategies highly suitable to its native arid environment. In general, flower and seed production is quite indeterminate, which permits the plant to exploit intermittent rainfall; and glume pair angle is fairly obtuse, which permits seed dispersal. Though persistence in the rangeland environment is the primary concern if this species is to be widely used in revegetation, seed must first be produced in a commercial seed production environment, where shattering is undesirable. Fortunately, objectives for the 2 environments are not necessarily conflicting. For example, a longer duration of seed retention is not a serious disadvantage on rangelands because the vast majority of retained seed is dispersed by the end of winter.

PI 478833 exhibits a more acute glume pair angle and a longer duration of seed retention than Paloma, explaining its 4-fold superiority in late-season seed retention index. PI 478833 also is an excellent seed producer. The relative indeterminacy of PI 478833 is considered an advantage for seed production because more of the seed is harvestable at a given time. Its shattering resistance, high seed yield, and relatively high floral determinacy combine to make PI 478833 a good potential genetic source for improvement of Indian ricegrass seed production efficiency.

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