

CENTRO AGRONÓMICO TROPICAL DE INVESTIGACION Y ENSEÑANZA
SUBDIRECCION GENERAL ADJUNTA DE ENSEÑANZA
PROGRAMA DE POSGRADO

Phenology, seed yield and physiological quality of Brachiaria
dictyoneura Stapf cultivated in Costa Rica

Tesis sometida a la consideración del Comité Técnico Académico del Programa de Estudios de Posgrado en Ciencias Agrícolas y Recursos Naturales del Centro Agronómico Tropical de Investigación y Enseñanza, para optar al grado de

Magister Scientiae

por

Stefano Diulgheroff

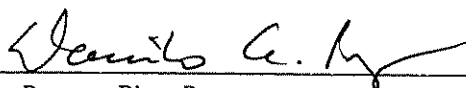
Centro Agronómico Tropical de Investigación y Enseñanza
Turrialba, Costa Rica

1991

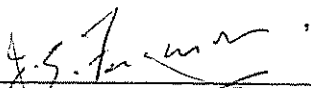
Esta tesis ha sido aceptada, en su presente forma, por la Coordinación del Programa de Estudios de Posgrado en Ciencias Agrícolas y Recursos Naturales Renovables del CATIE y aprobada por el Comité Asesor del estudiante como requisito parcial para optar al grado de:

MAGISTER SCIENTIAE

COMITE ASESOR:



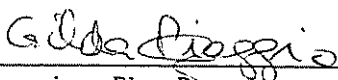
Danilo Pezo, Ph. D.
Profesor Consejero



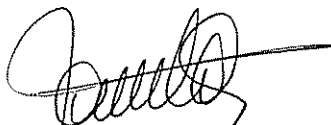
John Fergurson, Ph. D.
Miembro del Comité



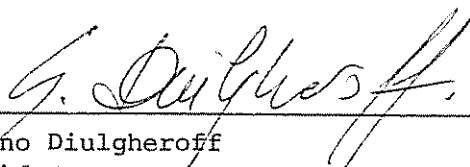
Pedro J. Argel, Ph. D.
Miembro del Comité



Gilda Piaggio, Ph. D.
Miembro del Comité



Ramón Lastra, Ph. D.
Jefe, Area de Posgrado



Stefano Diulgheroff
Candidato

To my mother Carla, my father Romano, my sister
Nicoletta, my brothers Marco and Peter.

Aknowledgments

This study would not have been possible without the financial support of the Italian Government, the Food and Agriculture Organization of the United Nations - FAO, the "Centro Internacional de Agricultura Tropical - CIAT" and the "Centro Agronómico Tropical de Investigación y Enseñanza - CATIE". For this I wish to extend my most grateful thanks to all those persons who on behalf of the Italian Government, FAO, CIAT and CATIE cooperated in such a support.

I am greatly indebted to Drs. John Ferguson, Pedro Argel, Danilo Pezo and Gilda Piaggio for their inestimable help and advice.

I would also like to thank Mr. "Robinson" and Mr. Manuel Montoya for their careful assistance with seed testing.

Table of Contents

Part I

Phenology of Brachiaria dictyoneura Stapf CIAT 6133 in Costa Rica

1.1. Introduction.....	1
1.2. Literature Review.....	1
1.3. Materials and Methods.....	4
1.3.1. Multiplication Sites.....	4
1.3.2. Seed Plot Management.....	5
1.3.3. Observations.....	6
1.4. Results and Discussion.....	8
1.5. Conclusions.....	15
1.6. References.....	16

Part II

Effect of Nitrogen Fertilization and Harvest Time on Seed Yield and Quality of Brachiaria dictyoneura Stapf CIAT 6133

2.1. Introduction.....	17
2.2. Literature Review.....	17
2.3. Materials and Methods.....	20
2.3.1. Field Experiment.....	20
2.3.1.1. Location.....	20
2.3.1.2. Experimental Design.....	20
2.3.1.3. Treatments.....	21
2.3.1.4. Harvest and Seed Management.....	21
2.3.1.5. Response Variables.....	21
2.3.2. Germination Test.....	22
2.3.3. Vigour Test.....	23
2.4. Results and Discussion.....	24
2.4.1. Inflorescence Density, Pure Seed Yield and	

Mean Seed Weight.....	24
2.4.2. Seed Quality.....	27
2.4.2.1. Germination Test.....	27
2.4.2.2. Vigour.....	31
2.4. Conclusions.....	31
2.5. References.....	32

Part III

Physiological Seed Quality

3.1. Introduction.....	36
3.2. Literature Review.....	38
3.2.2. Seed Structures Definition.....	38
3.2.3. Dormancy Definition.....	38
3.2.4. Biological Significance of Dormancy.....	39
3.2.5. Classes of Dormancy.....	40
3.2.6. Embryo Dormancy.....	41
3.2.6.1. Aspects of Physiology of Embryo Dormancy as related to Plant Hormones.....	42
3.2.6.2. Abscisic Acid (ABA).....	43
3.2.6.3. Gibberellins (GA).....	44
3.2.6.4. Cytokinins.....	45
3.2.6.5. Embryo Dormancy and the Phytochrome System..	45
3.2.7. Coat-Imposed Dormancy.....	46
3.2.7.1. Interference with Water Uptake.....	46
3.2.7.2. Interference with Gaseous Exchange.....	47
3.2.7.3. Presence of Inhibitors in the Coat and Prevention of their Escape.....	48
3.2.7.4. Mechanical Restriction.....	49
3.2.8. Some Factors Related with Dormancy Release....	49
3.2.8.1. Light.....	50
3.2.8.2. Alternating Temperature.....	50
3.2.9. After-Ripening in Dry Storage.....	51
3.2.10. Dormancy-Breaking Chemicals.....	52

3.2.10.1. Nitrate.....	52
3.2.10.2. Sulphuric Acid.....	54
3.2.11. Dry Heat as a Dormancy Breaking Pre-Treatment.....	54
3.3. Materials and Methods.....	56
3.3.1. Seed-Lot.....	56
3.3.2. Seed Storage Conditions.....	56
3.3.3. Separation of Pure Seed Spikelets.....	56
3.3.4. Moisture Content.....	58
3.3.5. Tetrazolium Viability.....	58
3.3.6. Total Viability.....	58
3.3.7. Germination.....	59
3.3.8. Relative Germination.....	59
3.3.9. Emergence.....	61
3.3.10. Acid Scarification.....	61
3.3.11. Early Patterns of Different Structures (Experiment 1).....	61
3.3.12. Effect of KNO_3 and H_2SO_4 on Dormancy.....	62
3.3.12.1. Experiment 2.....	63
3.3.12.2. Experiment 3.....	63
3.3.12.3. Experiment 4.....	63
3.3.12.4. Experiment 5.....	63
3.3.13. Effect of Heat on Dormancy.....	64
3.3.13.1. Experiment 6.....	64
3.3.13.2. Experiment 7.....	64
3.3.14. Models for Analyzing Sigmoid Progress Distributions.....	65
3.3.14.1. Logistic Model.....	65
3.3.14.2. Gompertz Model.....	66
3.3.14.3. Log-Logistic Model.....	66
3.3.15. Methodology of Application.....	67
3.4. Results and Discussion.....	68
3.4.1. Early Patterns of Different Structures (Experiment 1).....	68

3.4.2. Effect of KNO_3 and H_2SO_4 on Dormancy.....	74
3.4.3. General Synthesis.....	86
3.4.4.1. Scarification Effect.....	86
3.4.4.2. Potassium Nitrate Effect.....	89
3.4.5. Effect of Dry Heat on Dormancy.....	89
3.4.6. Models of the Dynamics of Relative Germination.....	96
3.4.6.1. Regression Analysis.....	96
3.4.6.2. Germination Patterns.....	106
3.4.6.2.1. Intact Seed.....	106
3.4.6.2.2. Intact Seeds Imbibed with KNO_3	107
3.4.6.2.3. Scarified Seeds Imbibed in Water.....	109
3.4.6.2.4. Scarified Seeds Imbibed with KNO_3	109
3.4.7. Estimated Dynamics of Scarification and Potassium Nitrate Effects.....	111
3.4.8. Dynamics of Embryo and Physical Dormancy.....	114
3.5. Conclusions.....	117
3.6. References.....	120

List of Tables

Table 1.1. Ecosystem, geographic coordinates and altitude of the three sites in Costa Rica.....	4
Table 1.2. Some meteorological parameters of the three sites in Costa Rica.....	4
Table 1.3. Chemical characteristics of the soil (0-20 cm) at the three sites in Costa Rica.....	5
Table 1.4. Location, plot size, sowing date and seed rate of the multiplication fields in Costa Rica.....	5
Table 1.5. Phenology of <u>Brachiaria dictyoneura</u> CIAT 6133 at three different sites in Costa Rica.....	11
Table 1.6. Pure seed yields of <u>B.dictyoneura</u> CIAT 6133 at three different sites of Costa Rica.....	15
Table 2.1. Principal geographical, climate and pedological parameters of the experimental site, Atenas.....	20
Table 2.2. Inflorescence density of <u>B.dictyoneura</u> CIAT 6133 for different N levels. Means and standard deviations are presented. Logarithmic transformations of data were used in the statistical analysis.....	24
Table 2.3. Pure seed yield (kg/ha) of <u>B.dictyoneura</u> CIAT 6133 for three N levels and three harvest times, Atenas 1990. Statistical analysis was conducted on logarithmic transformed data.....	25

Table 2.4. Mean weight (mg) of 100 spikelets of B. dictyoneura CIAT 6133 according to three N levels and three harvest times, Atenas 1990.....26

Table 2.5. Germination percent at six months post-harvest in a light-temperature alternating regime (20/35°C for 16/8 hours per day) of acid scarified B.dictyoneura CIAT 6133 spikelets imbibed with a solution of .2% of KNO₃. Final count (21st day).....28

Table 3.1. Brachiaria dictyoneura seed lots: origin, harvest date, moisture content, identification code and experiment number in which each lot has been utilized.....57

Table 3.2. Germination, total viability and relative germination of scarified with sulphuric acid and imbibed with potassium nitrate seeds from six seed-lots of B.dictyoneura CIAT 6133 of different ages, harvested in three localities of Costa Rica. Values are means of 3 replicates of 50 seeds...75

Table 3.3. Effect of concentrated H₂SO₄ for 30 minutes on total viability of seven seed-lots of B.dictyoneura CIAT 6133 of different ages, harvested at three localities in Costa Rica. Values are means of four replicates of 50 seeds.....77

Table 3.4. Relative germination in intact spikelets and in scarified, imbibed with potassium nitrate spikelets of seven seed-lots of B.dictyoneura CIAT 6133. Values are mean of three replicates of 50 seeds.....78

Table 3.5. Relative germination of intact and scarified spikelets imbibed with water and potassium nitrate of seed-lot of B.dictyoneura CIAT 6133 stored for 10.4 months. Values are means of 3 replicates of 50 seeds each.....79

Table 3.6. Effect of H_2SO_4 on intact seeds imbibed in water and in a solution of KNO_3 and effect of KNO_3 on intact and scarified seeds of B.dictyoneura CIAT 6133 at three times post-harvest. Effects are expressed as differences in relative germination.....80

Table 3.7. Effect of H_2SO_4 on intact seeds imbibed in water and in a solution of KNO_3 and effect of KNO_3 on intact and scarified seeds of two B.dictyoneura CIAT 6133 seed-lots. Effects are expressed as differences in relative germination.....83

Table 3.8. Explanation as for table 3.7. Effects are expressed as differences in germination percent on pure seeds basis.....85

Table 3.9. The effects of dry heat treatment (50°C for 10 days) on percentage emergence of intact, scarified and apically cut seed of B.dictyoneura CIAT 6133 stored for 8.3 months. Values are means of six replicates of 50 seeds each.....92

Table 3.10. Some linear regression statistic parameters of Gompertz and logistic models applied for the relative germination pattern of intact seeds of B.dictyoneura CIAT 6133.....98

Table 3.11. Some linear regression statistics of the Gompertz and logistic transformed relative germination from the four treatments applied to B.dictyoneura CIAT 6133 seed.....103

List of Figures

- Figure 1.1. Rainfall distribution and temperature during the experimental period at Atenas.....6
- Figure 1.2. Rainfall distribution and temperature during the experimental period at S. Isidro.....7
- Figure 1.3. Rainfall distribution and temperature during the experimental period at Guápiles.....7
- Figure 1.4.A Rainfall distribution and phenology of B. dictyoneura at S.Isidro from April to July 1988.....8
- Figure 1.4.B Rainfall distribution and phenology of B. dictyoneura at S.Isidro from April to July 1988.....9
- Figure 1.5. Rainfall distribution and phenology of B. dictyoneura at S.Isidro from April to July 1989.....9
- Figure 1.6. Rainfall distribution and phenology at Atenas from April to July 1988.....12
- Figure 1.7. Rainfall distribution and phenology of B. dictyoneura at Atenas from August to October 1988.....13
- Figure 1.8. Rainfall distribution and phenology of B. dictyoneura at Atenas from April to July 1989.....13
- Figure 1.9. Rainfall distribution and phenology of B. dictyoneura at Guapiles from April to July 1989.....14
- Figure 2.1. Daily rainfall and phenology of B.dictyoneura at

Atenas during the experimental period (April-July 1990)....23

Figure 2.2. Cumulative germination during the testing period of B.dictyoneura CIAT 6133 seeds produced under different N fertilization levels and stored for six months.....28

Figure 2.3. Cumulative germination during the testing period of B.dictyoneura CIAT 6133 seeds produced under different N fertilization levels and stored for 10.4 months.....30

Figure 2.4. Shoot axis, root and seedling length of B. dictyoneura CIAT 6133 seeds produced under three N fertilization levels. Measurements were done at the 21st day of the vigour test. Points on each line with the same letter are not significantly different (P<.05).....30

Figure 3.1. Dynamics of tetrazolium viability and germination of intact spikelets of B.dictyoneura CIAT 6133 from A90a seed-lot during the first year after harvest.....69

Figure 3.2. Dynamics of germination of free caryopsis and intact spikelets of B.dictyoneura CIAT 6133 from A90a seed-lot during the first year after harvest.....69

Figure 3.3. Dynamics of germination of H₂SO₄ scarified and KNO₃ imbibed seed of B.dictyoneura CIAT 6133 from A90a seed-lot during the first year after harvest.....72

Figure 3.4. Dynamics of emergence of H₂SO₄ scarified spikelets, free caryopses and intact spikelets of B.dictyoneura CIAT 6133 from A90a seed-lot during the first six months after harvest.....73

Figure 3.5. Dynamics of the effect of H₂SO₄ scarification on

Relative Germination of spikelets of B.dictyoneura CIAT 6133 imbibed with water.....87

Figure 3.6. Dynamics of the effect of H₂SO₄ scarification on Relative Germination of spikelets of B.dictyoneura CIAT 6133 imbibed with KNO₃.....87

Figure 3.7. Dynamics of the effect of KNO₃ on Relative Germination of intact spikelets of B.dictyoneura CIAT 6133.....88

Figure 3.8. Dynamics of the effect of KNO₃ on Relative Germination of H₂SO₄ scarified spikelets of B.dictyoneura CIAT 6133.....88

Figure 3.9. Regression curve between germination of apically cut spikelets of B.dictyoneura CIAT 6133 from A90a seed-lot (six months after ripen) and dry heat exposure time.....90

Figure 3.10. Relative germination of intact seeds imbibed in water, from seven seed-lots of B.dictyoneura CIAT 6133 plotted against time. Values from the same seed-lot are joint by a line.....94

Figure 3.11. Relative germination of intact seeds imbibed in a potassium nitrate solution, from seven seed-lots of B.dictyoneura CIAT 6133 plotted against time. Values from the same seed-lot are joint by a line.....94

Figure 3.12. Relative germination of scarified seeds imbibed in water, from seven seed-lots of B.dictyoneura CIAT 6133 plotted against time. Values from the same seed-lot are joint by a line.....95

Figure 3.13. Relative germination of scarified seeds imbibed in a potassium nitrate solution, from seven seed-lots of B.dictyoneura CIAT 6133 plotted against time. Values from the same seed-lot are joint by a line.....95

Figure 3.14. Linear regression of relative germination transformed by Gompertz equation versus post-harvest time. Intact seeds imbibed with water from seven seed-lots of B.dictyoneura CIAT 6133.....97

Figure 3.15. Linear regression of relative germination transformed by Gompertz equation data versus post-harvest time. Intact seeds imbibed with potassium nitrate from seven seed-lots of B.dictyoneura CIAT 6133.....99

Figure 3.16. Linear regression of relative germination transformed by Gompertz equation data versus post-harvest time. Scarified seeds imbibed with water from seven seed-lots of B.dictyoneura CIAT 6133.....99

Figure 3.17. Linear regression of relative germination transformed by Gompertz equation data versus post-harvest time. Scarified seeds imbibed with potassium nitrate from seven seed-lots of B.dictyoneura CIAT 6133.....100

Figure 3.18. Linear regression of relative germination transformed by Gompertz equation data versus logarithm of post-harvest time. Intact seeds imbibed with potassium nitrate from seven seed-lots of B.dictyoneura CIAT 6133...101

Figure 3.19. Linear regression of relative germination transformed by Gompertz equation data versus logarithm of post-harvest time. Scarified seeds imbibed with water from seven seed-lots of B.dictyoneura CIAT 6133.....101

Figure 3.20. Linear regression of relative germination transformed by Gompertz equation data versus logarithm of post-harvest time. Scarified seeds imbibed with potassium nitrate from seven seed-lots of B.dictyoneura CIAT 6133...102

Figure 3.21. Linear regression of relative germination transformed by the logistic equation versus post-harvest time. Intact seeds imbibed with water from seven seed-lots of B.dictyoneura CIAT 6133. Data not included in the regression analysis are represented by a cross (+).....104

Figure 3.22. Linear regression of relative germination transformed by Gompertz equation versus post-harvest time. Intact seeds imbibed with potassium nitrate from seven seed-lots of B.dictyoneura CIAT 6133. Data not included in the regression analysis are represented by a cross (+).....104

Figure 3.23. Linear regression of relative germination transformed by Gompertz equation versus post-harvest time. Scarified seeds imbibed with water from seven seed-lots of B.dictyoneura CIAT 6133. Data not included in the regression analysis are represented by a cross (+).....105

Figure 3.24. Linear regression of relative germination transformed by Gompertz equation versus post-harvest time. Scarified seeds imbibed with potassium nitrate from seven seed-lots of B.dictyoneura CIAT 6133. Data not included in the regression analysis are represented by a cross (+)....105

Figure 3.25. Relative germination pattern of intact seeds of B.dictyoneura CIAT 6133 from 2 to 34 months post-harvest..106

Figure 3.26. Relative germination pattern of imbibed with

potassium nitrate, seed of B.dictyoneura CIAT 6133 from 2 to 34 months post-harvest.....108

Figure 3.27. Relative germination pattern of acid scarified seed of B.dictyoneura CIAT 6133 from 2 to 34 months post-harvest.....108

Figure 3.28. Relative germination pattern of scarified, imbibed with potassium nitrate, seed of B.dictyoneura CIAT 6133 from 2 to 34 months post-harvest.....110

Figure 3.29. Observed and estimated effects during post-harvest time of scarification on relative germination of seeds of B.dictyoneura CIAT 6133 imbibed with water.....112

Figure 3.30. Observed and estimated effects during post-harvest time of scarification on relative germination of seeds of B.dictyoneura CIAT 6133 imbibed with potassium nitrate.....113

Figure 3.31. Observed and estimated effects during post-harvest time of potassium nitrate on relative germination of intact seeds of B.dictyoneura CIAT 6133.....113

Figure 3.32. Observed and estimated effects during post-harvest time of potassium nitrate on relative germination of scarified seeds of B.dictyoneura CIAT 6133.....114

Figure 3.33. Dynamics of physical and embryo dormancy in B.dictyoneura CIAT 6133 seed.....117

Fenology, seed yield and physiological quality of Brachiaria dictyoneura Stapf grown in Costa Rica.

Summary

Brachiaria dictyoneura CIAT 6133 is a grass well adapted to infertile and acid soils, highly promising in evaluations conducted in Central America. Since 1988, its reproductive behaviour has been studied in three different ecosystems in Costa Rica; in two of them (Semi-ever green and Sub-humid tropical forest) two well defined peaks of flowering, in june and october, as well as cyclical fluctuations in pure seed yield (PSY) have been observed.

The effect of three nitrogen levels (0, 75, 150 kg/ha), supplied to the crop a week before flowering and the effect of three harvest time (0, +4, +8 days) upon PSY and seed quality were studied at Atenas in 1990. Results showed that late nitrogen fertilization did not affect inflorescence density and PSY. Conversely, harvest time markedly influenced PSY, reflecting a highly synchronized flowering and seed ripening. High nitrogen levels applied a week before flowering were shown to increase seed unit weight as well as seed vigour, in terms of germination speed.

The physiological quality of B.dictyoneura seeds was characterized by tetrazolium viability, gemination and emergency tests up to 34 months after harvest. Two different types of seed dormancy have been detected, one physiological, the other physical, imposed by the palea and lemma. The embryo dormancy (physiological) represents the main limiting factor to germination in this species grown in Costa Rica. It can be overcome in intact spikelets by almost a two year storage period at 20°C and 40% relative humidity. In fresh seeds, potassium nitrate, supplied in a variable light and

temperature regime, was shown to reduce only partially the physiological dormancy. Otherwise, the physical dormancy imposed by covering structures seems to operate as a barrier reducing permeability of gases and NO_3^- ions. The presence of germination inhibitors located in the glumes cannot be excluded, while mechanical constraints to radicle emergence exerted by seed coverings do not seem to play any role in this species. During the first two years in storage at 20°C , the physical dormancy can be completely overcome by an H_2SO_4 scarification without significantly affecting seed viability. Seed age, acid scarification and nitrate imbibition positively interact to overcome seed dormancy. The positive effect of H_2SO_4 scarification in seeds imbibed with KNO_3 on reducing seed dormancy cannot be appreciated before a post-harvest three months period under storage conditions during which after-ripening of seeds begins to occur. Maximum effect on dormancy is reached six months post-harvest by applying both chemicals, or 8-10 months post-harvest by applying only one of them. Dry heat can increase germination by reducing physical dormancy, according to the temperature, exposure time and, possibly, to the seed after-ripening status. Relative germination (RG) is a relevant parameter to compare germination values among different seed-lots. Its use allows to describe the dynamics of germination of intact and scarified seeds, either imbibed with water and/or KNO_3 . RG distribution in the four treatments ($\pm\text{H}_2\text{SO}_4 \times \pm\text{NO}_3$) presents a sigmoid pattern.

The logistic model is appropriate to describe such distribution in intact seeds, while the Gompertz model better fits to the other treatments. Both physical and embryo dormancy in seeds of B. dictyoneura CIAT 6133 cultivated in Costa Rica follows a sigmoid distribution, being completely released after about 2 years of after-ripening in a controlled environment. Embryo dormancy reached values of

approximately 50% at the 9th month post-harvest while the physical at the 16th.

Fenología, rendimiento y calidad fisiológica de la semilla de Brachiaria dictyoneura Stapf cultivada en Costa Rica.

Resumen

Brachiaria dictyoneura CIAT 6133 es un pasto adaptado a condiciones de suelos ácidos e infértiles, altamente promisorio en las evaluaciones realizadas en Centro América. Desde 1988, el comportamiento reproductivo ha sido estudiado en tres diferentes ecosistemas de Costa Rica, donde la accesión muestra dos picos de floración bien definidos, en junio y octubre, y fluctuaciones cíclicas de rendimiento de semilla pura (RSP).

El efecto de tres niveles de nitrógeno (0, 75, 150 kg/ha), aplicado una semana antes de la floración y el efecto de tres épocas de cosecha (0, +4, +8 días) sobre RSP y la calidad de la semilla se estudiaron en Atenas en 1990. Los resultados indican que la fertilización nitrogenada tardía no tiene efecto sobre la densidad de nflorescencias y RSP, mientras que la época de cosecha afecta marcadamente RSP, reflejando una floración y una maduración de la semilla altamente sincronizada. Altos niveles de nitrógeno aplicado poco antes de la floración incrementan el peso unitario y el vigor de la semilla en términos de velocidad de germinación.

La calidad fisiológica de la semilla se caracterizó a través de pruebas de viabilidad en tetrazolio, germinación y emergencia hasta los 34 meses post-cosecha. Dos formas de latencia han sido detectadas, una fisiológica, la otra física, impuesta por la lemma y la palea. La latencia embrional (fisiológica) representa el principal factor limitante de la germinación de esta especie cultivada en Costa Rica. Esta puede ser superada en espiguillas intactas por medio de un periodo de almacenaje de casi dos años. En semilla recién cosechada, el KNO_3 puede reducir sólo en forma

parcial dicha latencia en un regimen de luz y temperatura variables. En contraste, la latencia impuesta por las glumas parece operar reduciendo los intercambios gaseosos, pero, también como barrera impermeable a los iones NO_3^- . La presencia de inhibidores de la germinación a nivel de las glumas no puede ser excluida, mientras que restricciones de caracter mecánico a la emergencia radicular no parecen jugar ningún papel en esta especie. Durante los dos primeros años de almacenamiento a 20°C , la latencia física puede ser eliminada completamente por medio de la escarificación con H_2SO_4 , sin afectar en forma significativa la viabilidad de la semilla. La edad de la semilla, la escarificación y la imbibición con nitrato son factores que interactúan positivamente en eliminar la latencia. Por lo menos se necesitan tres meses de post-maduración antes que la escarificación con ácido, combinada al tratamiento con nitrato, sea efectiva en reducir parcialmente la latencia de la semilla. El máximo efecto de ambos químicos se alcanza seis meses post-cosecha, si se aplican combinados, u 8-10 meses post-cosecha, aplicando uno sólo de estos. El calor seco puede incrementar la germinación reduciendo la latencia física, de acuerdo a la temperatura, el tiempo de exposición a ésta y, posiblemente, al estado de post-maduración de la semilla. La germinación relativa (GR) es el parámetro de más relevancia para comparar valores de germinación entre diferentes lotes. Su uso permite describir la dinámica de la germinación de semilla intacta y escarificada, imbibidas con y sin KNO_3 . La evolución en el tiempo de GR en los cuatro tratamientos presentó una distribución sigmoide.

El modelo logístico es apropiado para interpretar tal distribución en espiguillas intactas, mientras que el de Gompertz se ajusta mejor a las distribuciones de los otros tratamientos. Ambas latencias, física y embrional, siguen un patrón sigmoide, siendo eliminadas completamente después de

dos años de post-maduración en un ambiente controlado (20°C y 40% de humedad relativa). La latencia embrional alcanza valores del 50% aproximadamente al 9° mes post-cosecha, y la física al 16° mes.