EFFICACY OF SIX TYPES OF GERMINATING MEDIA IN BREAKING DORMANCY OF TQR-2 PADDY SEEDS

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2011
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DECLARATION

I hereby declare that this dissertation is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that no part of this dissertation has been previously or concurrently submitted for a degree at this or any other university.

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ABSTRACT

This study was conducted at the School of Sustainable Agriculture Laboratory in Universiti Malaysia Sabah, Kota Kinabalu, Sabah to evaluate the efficacy of six types of germinating media in breaking the dormancy of TQR-2 paddy seeds and to find out how effective was clean collected rain water in breaking the seed dormancy. The freshly harvested TQR-2 paddy seeds were soaked in different treatment solutions including 0.2 N HNO₃ (control), 0.2 N H₂SO₄, 0.2 N HCl, distilled water, tap water and rain water for 12 hours. Then, the seeds were germinated in germination boxes and were observed for 14 days. Complete Randomized Design was used in this experiment with three replications for each treatment. Data for important parameters such as the percentage of seed germination, percentage of normal seedling, percentage of abnormal seedling, number of leaves, seedling height and the length of primary root were analysed by one-way ANOVA. The 0.2 N HNO₃ (control) resulted in the highest percentage of seed germination (92.67%) followed by rain water treatment (74.67%). However, 0.2 N HNO₃ (control) resulted in a high percentage of abnormal seedlings (11.29%) as compared to rain water treatment (4.04%). The lowest percentage of germination was from the distilled water treatment (19.67%). Taking into consideration the percentage of seed germination and percentage of normal and abnormal seedlings, it can be concluded that rain water is the second best to 0.2 N HNO₃ in breaking the dormancy of TQR-2 paddy seeds. Therefore, clean collected rain water which is free and abundantly available during rainy season is a good alternative and an efficient agent for breaking the seed dormancy. It can also be recommended to paddy farmers to overcome the problem of any newly harvested paddy variety seeds that are dormant.
ABSTRAK

Satu kajian telah dijalankan di Makmal Sekolah Pertanian Lestari, Universiti Malaysia Sabah, Kota Kinabalu, Sabah untuk mengkaji keberkesanan enam jenis medium percambahan dalam memecahkan dormansi biji benih padi varieti TQR-2 serta megkaji keberkesanan air hujan untuk memecahkan dormansi tersebut. Benih padi varieti TQR-2 direndam dalam rawatan 0.2 N HNO₃ (kawalan), 0.2 N H₂SO₄, 0.2 N HCl, air suling, air paip dan air hujan selama 12 jam. Benih padi dicambah dalam bekas percambahan dan diperhatikan selama 14 hari. Reka bentuk secara rawak (Complete Randomized Design) diaplikasikan dalam eksperimen ini dengan tiga replikasi bagi setiap rawatan. Pada akhir eksperimen, parameter penting seperti peratus percambahan, peratus benih normal, peratus benih abnormal, bilangan daun, tinggi anak benih serta panjang akar primer dianalisis dengan ANAVA sehala. Keputusan menunjukkan rawatan 0.2 N HNO₃ (kawalan) memberi peratus percambahan yang tertinggi (92.67%) diikuti dengan rawatan air hujan (74.67%). Namun demikian, peratus benih abnormal bagi rawatan 0.2 N HNO₃ (kawalan) adalah tinggi (11.29%) jika dibandingkan dengan rawatan air hujan (4.04%). Di samping itu, peratus percambahan terendah diperolehi daripada rawatan air suling (19.67%). Dengan mengambil kira peratus percambahan dan peratus benih normal dan abnormal, dapat disimpulkan bahawa air hujan adalah kedua terbaik untuk memecahkan dormansi biji benih padi varieti TQR-2 selain daripada 0.2 N HNO₃. Oleh itu, air hujan yang senang diperolehi pada musim hujan didapati berkesan untuk memecahkan dormansi biji benih padi varieti TQR-2. Dengan itu, air hujan boleh dicadangkan kepada para petani untuk mengatasi masalah dormansi pada biji benih padi yang baru dituai.
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<tr>
<td>ANOVA</td>
<td>Analysis of Variance</td>
</tr>
<tr>
<td>DAS</td>
<td>Day after sowing</td>
</tr>
<tr>
<td>DAT</td>
<td>Day after transplanting</td>
</tr>
<tr>
<td>M</td>
<td>Molarity</td>
</tr>
<tr>
<td>N</td>
<td>Normality</td>
</tr>
<tr>
<td>SPSS</td>
<td>Statistical Package for Social Science</td>
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</tbody>
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CHAPTER 1

INTRODUCTION

1.1 Introduction

Seed dormancy can be defined as a state at which seeds are prevented from germinating even under favourable conditions. Seed dormancy is a genetically inherited trait (Naylor, 1983) whose intensity is modified by the environment during seed development. Domesticated plants generally show less dormancy compared to wild species. Domesticated species that exhibit dormancy can be a problem for the seed producer. However, a degree of dormancy is required by some crop species in order to prevent pre-harvest sprouting and to maintain seed quality (Copeland and McDonald, 2001).

Paddy, a staple food crop in Asian countries is a monocotyledon plant whose seed consists of three main components namely embryo, endosperm and pericarp. Paddy has a hypogeal germination characteristic. During germination, its cotyledons (storage organ) remain beneath the soil while the plumule pushes upward and emerges above ground. The epicotyl will rapidly elongate while cotyledons will continue to provide nutritive support to the growing point throughout germination regardless of their above or below ground location (Copeland and McDonald, 2001).

Usually, germination of paddy seeds need water, oxygen, light and suitable temperature. However, some paddy species do not germinate even under these favourable conditions and they are thought to have undergone a certain period of dormancy. Seed dormancy has been reported to occur among varieties grown in all the major rice producing areas of the world such as China (Tang and Chiang, 1955) and Malaysia (Dore, 1955). Seed dormancy is more common in freshly harvested seeds. Several reviews of the occurrence of seed dormancy in rice indicate that it causes
serious problems to cropping practices (International Rice Research Institute, 1968). Environmental factors such as temperature, oxygen and moisture can modify the expression of dormancy which is a heritable trait (Tomar, 1984; Rao, 1985).

According to Salehah (2008), seed dormancy has been found in several paddy varieties such as TQR-1, TQR-2, IR 54, IR 72, TR 7 and MR 159 released by the Department of Agriculture Sabah. Among these six paddy varieties, it has been found that TQR-1 and TQR-2 paddy varieties have the longest period of seed dormancy.

In order to break the paddy seed dormancy, chemical scarification method can be used. The seeds are treated with chemicals such as sulphuric acid, nitric acid and hydrochloric acid. This method can imitate the acid condition in soil which can lead to the breaking of seed dormancy. The acids can cause degradation of seed coat, hence permits water and gases to penetrate or absorbed into the seed. Other compounds such as sodium hypochlorite and hydrogen peroxide have also been reported to scarify seeds (Hsiao and Quick, 1984). In addition, plant hormones such as gibberellins, auxins and cytokinins are also effective in breaking exogenous seed dormancy. However, it is difficult to obtain the plant hormones for the purpose of breaking of seed dormancy and they are expensive and can not be afforded by ordinary farmers.

Seed dormancy can also be broken by soaking seeds in water. The early stages of imbibition or water uptake into a dry seed are a crucial period for seedling germination and it is the first key event that moves the seed from the dry, quiescent and dormant seed to the resumption of embryo growth. In addition, mechanical scarification can also be done in order to break the seed dormancy. Other techniques such as heating, drastic temperature shift and brief immersion in boiling water are also effective for the breaking of seed dormancy.

1.2 Justification

Seed dormancy always happens for seeds of traditional tropical rice varieties and also other different Oryza sativa varieties (Misra and Misro, 1970). The breaking of seed dormancy is important because paddy is the staple food crop in Asian countries and it is of great economic importance.
There were two reasons why this study was to be proposed. The first was various degrees of dormancy had been reported in the three subspecies of *O. sativa* (Nakamura, 1963; IRRI, 1968; Sukumara Dev, 1982). Of these, indica is the most dormant followed by javanica and japonica (Ellis *et al.*, 1983). Seed dormancy is more common in freshly harvested seeds and if undetected can seriously effect field establishment. In addition, most traditional rice varieties of tropical Asia have strong grain dormancy. The occurrence of seed dormancy has seriously interfered with the establishment of two or three successive crops in a year which is a pattern common in Asia. Several reviews of the occurrence of seed dormancy in rice also indicate that it causes serious problems to cropping practices (Mouton, 1960; Pili, 1968; International Rice Research Institute, 1968). Seed dormancy can also be a problem to seed analysts (Copeland and McDonald, 2001) who need to determine the seed germination capacity and the plant breeder who needs to reduce the time interval between crops. Therefore, breaking of seed dormancy is crucial in order to enable dormant seeds to germinate at the desired time.

Secondly, by doing this study the simplest and the most effective method for farmers to break the paddy seed dormancy could be determined which could directly help to reduce farmers' burden in looking for the best and simple method for breaking the dormancy. According to De Datta (1981), farmers usually have to wait until the dormancy period is over or break the dormancy by heat (50°C for five days) before they can sow the seeds. However, the usual practice is to wait until the end of the dormancy period and this will greatly affect the cropping time planned by farmers. In addition, the seeds of most traditional tropical rice varieties will also not germinate immediately after harvest. They have a period of dormancy of several weeks or longer and this can be a real disadvantage if the farmer wants to grow the same variety the year round and depends on the preceding crop as a source of seed. Therefore, farmer must be able to break the seed dormancy.

In addition, besides acid solutions, distilled water can also be used for breaking paddy seed dormancy (Bushra, 2010). Hence, the effectiveness of using clean collected rain water for breaking paddy seed dormancy was the focus of this study because rain water was free and available abundantly during rainy season. If it was proven to be an efficient agent as germination medium for breaking seed dormancy, it would be of great benefit to paddy farmers.
1.3 Objectives

The objectives of this study were:

(1) To assess the efficiency of six types of germinating media in breaking TQR-2 paddy seeds dormancy
(2) To find out how effective is clean collected rain water in breaking TQR-2 paddy seeds dormancy

1.4 Hypothesis

\( H_0 \): There was no significant difference on the germination percentages of TQR-2 paddy seeds treated with different germinating medium in breaking the seed dormancy

\( H_1 \): There was significant difference on the germination percentages of TQR-2 paddy seeds treated with different germinating medium in breaking the seed dormancy
CHAPTER 2
LITERATURE REVIEW

2.1 Paddy

Paddy or rice is an annual grass (Gramineae) which belongs to the genus *Oryza*. There are 23 species of genus *Oryza* of which 21 are wild and two are cultivated species, *Oryza sativa* (Asian rice) and *Oryza glaberrima* (African rice). Among these two cultivated species, *O. sativa* is the most commonly grown throughout the world. *O. sativa* in Asia has been differentiated into three subspecies based on the geographic conditions. They are indica (long grained), japonica (short grain) and javanica (intermediate type).

2.1.1 TQR-2 Paddy Variety

TQR-2 paddy variety is a cross between B6555B-199-40 and Baruman. It has good grain quality and high yield potential. The maturation period is 120 to 125 days. The plant height is 80 to 105 cm and is moderately resistant to lodging. It is resistant to several diseases such tungro, rice blast and bacterial leaf blight (Pusat Penyelidikan Pertanian Tuaran, 2007). According to Salehah (2008), the seed of TQR-2 paddy variety has shown signs of dormancy.

2.2 Seed Certification

Seed certification is a program to maintain and make available to the public high quality seeds (Copeland and McDonald, 2001). Certification guarantees that a line of seed is of pure variety and it has reached certain minimum standards of purity and germination (Schwass and Allo, 1973). Usually, uncertified seed has a very low
germination percentage which is an undesirable feature. Some uncertified seeds might even show long duration of dormancy which can greatly affect the activities of farmers, seed analysts and seed producers. Therefore, seed certification is crucial in order to obtain quality seed with high purity germination rate and vigour.

2.2.1 Generation Scheme of Certification

The four generation schemes of certification are breeder seeds, foundation seeds, registered seeds and certified seeds. Breeder seeds are produced under the direct supervision and they represent the true pedigree of the variety. Foundation seeds are the first generation seeds from breeder seeds. They are produced under contract by a foundation seed organisation and they are labelled by white certification tags. Registered seeds are produced from foundation seeds. They are a non-commercial seed class and they are used as the planting stock for certified seed producer. These registered seeds are labelled by purple seed tags. Certified seeds are produced from foundation or registered seeds. They represent the final product of certification program and they are labelled by blue tags.

2.2.2 Certification Procedure

A proper planting stock is essential as it provides a pedigree which is a central to the certification concept (Copeland and McDonald, 2001). After having a proper planting stock, an application for certification must be submitted to the appropriate certifying agency requesting certification as foundation, registered or certified seed. Timely field inspections will be performed during planting period so that varietals off-types and other crops and weeds contamination are easily detected. During harvesting, more care is given to moisture content, purity and prevention of mechanical damage. Seed harvested with excessive moisture content will not maintain its quality during storage. All seeds must be cleaned in order to remove other inert matters and weed seeds. The sample will be tested for determining the seed quality and acceptance for certification. Then, a sample of conditioned seed will be tested for the purity, germination and noxious seed content. The analysis information such as purity and germination will be printed on the certification tag (Copeland and McDonald, 2001).
2.3 Seed Dormancy

2.3.1 Types of Dormancy

Seed dormancy can be defined as a state at which seeds are prevented from germinating even under favourable conditions. Seed dormancy is a genetically inherited trait (Naylor, 1983) whose intensity is modified by the environment during seed development. Domesticated plants generally show less dormancy compared to wild species. Domesticated species that exhibit dormancy can be a problem for the farmer, seed producer, seed analyst and plant breeder. However, a degree of dormancy is required by some crop species in order to prevent pre-harvest sprouting and to maintain seed quality (Copeland and McDonald, 2001).

Dormancy in seed can be of two forms - primary and secondary. Primary dormancy is the most common form of seed dormancy and it can be further classified into exogenous and endogenous dormancy.

Exogenous dormancy is a condition in which the essential germination components are not available to the seed for examples water, oxygen, light and temperature. This can make seed fails to germinate. The physical properties of seed coat are usually related to this type of dormancy. In addition, the environmental stimuli such as light and oxygen which favourable for germination may also be absent. There are several factors that responsible for exogenous dormancy such as water, gases and mechanical restriction. Impermeability of seed coat to water and gases is always happened in hard seed and it can be caused by both genetic and environmental factors. Dormancy has also been caused by physical restraint by the seed coats on an enlarging embryo (Copeland and McDonald, 2001).

Endogenous dormancy is due to the inherent properties of seed. There are two types of endogenous dormancy - rudimentary embryo dormancy and physiological dormancy. Rudimentary embryo dormancy is due to the immature embryo and it is not able to germinate. For physiological dormancy, it may be a result of the presence of growth inhibitors, the absence of growth promoter and a combination of both (Copeland and McDonald, 2001).
Secondary dormancy is caused by exposure of seed to conditions that favour germination in all aspects except one and this making non-dormant seeds encounter conditions that subsequently cause them to become dormant.

2.3.2 Dormancy in Paddy Seed

There are two important species of rice used as major crops on a world basis (Purseglove, 1972), namely indica (long grain) and japonica (short grain). They are grown throughout the tropical and subtropical regions of the world. Seeds of most indica and other photoperiodic rices have dormancy that can last up to three months (Purseglove, 1972) and this can seriously interfere with the establishment of two or three successive crops in a year which is a pattern common in Asia. Several reviews of the occurrence of seed dormancy in rice indicate that it causes serious problems to cropping practice (International Rice Research Institute, 1968).

Various degrees of dormancy have been reported in the three subspecies of *O. sativa* (Nakamura, 1963; IRRI, 1968; Sukumara Dev, 1982). Of these, indica is the most dormant followed by javanica and japonica (Ellis *et al.*, 1983). Seed dormancy is more common in freshly harvested seeds and if undetected can seriously effect field establishment. Usually, the processed seeds are stored for a period of approximately two to four months before re-sowing in the next season. This allows the remaining dormant seeds to after ripen and decrease the incidence of dormancy. However, occasional batches of rice containing a high proportion of dormant seeds are still encountered. This is due to the shorter after-ripening period and improper drying of relatively dormant varieties. When such seed lots are identified in pre-sowing test, it is recommended that the rice seeds are soaked overnight up to 16 hours in the nitric acid with concentration of 3 M in order to break the dormancy.

Seed dormancy can actually occur among species of *Oryza* (Morishima and Oka, 1959; Misra and Misro, 1970) and among varieties within species (Roy and Gupta, 1976). The variation in the degree of dormancy can also be occurred within a single panicle.

Environmental factors such as temperature, oxygen and moisture can modify the expression of dormancy which is a heritable trait (Tomar, 1984; Rao, 1985). In a
research which including 18 local paddy varieties, it is found that seeds from an area with high rainfall will have a longer period of dormancy compared to the area with low rainfall during seed maturation (Halimathul Saadiah, 1991).

Table 2.1 Dormancy in some local paddy varieties in different seasons and locations

<table>
<thead>
<tr>
<th>Dormancy (month)</th>
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<tr>
<td>&lt; 1</td>
<td>Masria, Muda 2, Pulut Malaysia 1, Muda, Ria, MR84, Makmur, MR85, Seri Malaysia 1</td>
<td>Masria, Muda 2, Seri Malaysia 2, Ria, MR 101</td>
</tr>
<tr>
<td>1 – 3</td>
<td>Bahagia, Jaya, Seberang, Manik, Murni, Malinja, Sekembang, Sekincang, Kadaria, Setajung, MR82</td>
<td>Pulut Siding, Muda, MR84, Makmur, Malinja, Mahsuri mutan, Kadaria, Sekincang, Mahsuri, MR81, Pulut Malaysia 1, Seri Malaysia 1, Jaya, Improved Mahsuri, Setajung, Manik, Seberang, Sekembang, Bahagia</td>
</tr>
<tr>
<td>&gt; 3</td>
<td>None</td>
<td>Murni, Kadaria</td>
</tr>
</tbody>
</table>

Source: MARDI

According to MARDI, there are 18 local paddy varieties which showing a range of 4 to 83 days of dormancy (Refer Table 2.1). For paddy variety 'Seberang', the moisture content of seed decreased rapidly from 60% to 30% one week after flowering. After that, the rate of moisture removal from seed slows down and the accumulation of dry matter is in a linear rate and achieves its maximum 21 days after flowering. The seed germination percentage is low (only 10%) at this stage and will only increase after this. On the other hand, the germination percentage is only 30% on 39 days after flowering. This is due to seed dormancy. Certain treatment can be given to the dormant paddy seeds in order to break the dormancy.

According to Roberts (1961), most rice species have tightly adhering hulls (lemma and palea) that remain attached after seed is shed from the parent plant. These have implicated as causal factors in seed dormancy.
Dormancy in paddy seed not only caused by the hard seed coat which preventing the penetration of water and gases, but it can also cause by chemical inhibitor on the seed coat (Patil and Zode, 1990). In paddy seed, the level of abscisic acid (ABA) in non-dormant seed reduced rapidly on the early stage of seed maturation, however, in dormant seed, the abscisic acid level will reduce slowly (Hayashi, 1987). Abscisic acid is the inhibitor of seed germination and occurs in high concentration in dormant seed.

Usually, the seeds of traditional tropical rice varieties will not germinate immediately after harvest. They will have a period of dormancy of several weeks or longer (Yoshida, 1981). This can be a valuable characteristic in tropical rice areas where the rain and high humidity frequently occur during the harvest period in order to prevent pre-harvest sprouting. However, it can be a real disadvantage if the rice seed dormancy is longer than two to three weeks when the farmer needs to grow the same variety the year round and depends on the preceding crop as a source of seed Therefore, farmer must be able to break the seed dormancy.

2.3.3 Advantages and Disadvantages of Seed Dormancy

The ability of seeds to delay their germination until the time and place are right is an important survival mechanism in plants (Copeland and McDonald, 2001) and this is closely related to seed dormancy. Seed dormancy enables plants to survive under the adverse natural conditions. According to De Datta (1981), seeds for many tropical rice varieties have a dormancy period of two to three weeks and this is an important advantage in the tropics especially for the wet season crop when high temperature and humidity at harvest would result in germination on panicle if there is no dormancy. In addition, a degree of dormancy in certain crops such as winter cereal is also desirable since it prevents pre-harvest sprouting and helps to maintain seed quality (Copeland and McDonald, 2001).

However, when domesticated species exhibit dormancy, they can become a problem to seed producer, seed analyst (Copeland and McDonald, 2001) and plant breeder who needs to reduce the time interval between crops. According to Purseglove (1972), seed dormancy in rice can last up to three months and this can seriously interfere with the establishment of two and three successive crops in a year which is a
pattern common in Asia. In addition, several reviews of the occurrence of seed dormancy in rice also indicate that it causes serious problem in practice of cropping (Mouton, 1960; Pili, 1968; International Rice Research Institute, 1968). On the other hand, seeds of most traditional tropical rice varieties have also been found to have a long period of dormancy and this can be a real disadvantage if the farmer wants to grow the same variety the year round and depends on the preceding crop as a source of seed. This can greatly affect the cropping time planned by farmer. Therefore, the breaking of seed dormancy is of great importance.

2.3.4 Relationship of Dormancy and Seed Storage

Storage can affect seed dormancy in many instances. A major problem facing by seed technologists when testing stored seed for germination is how to overcome dormancy. In most crop species, dormancy can be dissipated within a few to several months when the seeds are stored at ambient temperature with high percentage of relative humidity. According to Brown et al. (1948), dormancy is overcome in many cultivars of barley and sorghum within one to six months when stored at 40°C.

On the other hand, the best method of maintaining seeds dormancy is to store them at subfreezing temperatures (Justice and Bass, 1978). According to Larson et al. (1936), the duration of dormancy can be increased by lowering the temperature.

Dormant seeds in storage undergo changes, some of which lead to breaking of dormancy and some to inducing dormancy. Some of these changes are affected by storage conditions (Justice and Bass, 1978).

2.4 Methods of Breaking Seed Dormancy

In order to enable dormant seed to germinate, several methods for breaking seed dormancy such as mechanical scarification, chemical scarification, soaking in water, stratification, temperature shifting, light treatment and chemical promotion of seed germination have been practised.
Mechanical scarification is used to break exogenous seed dormancy where the seed coat is not permeable to water and gases. Seed can be rubbed with sand paper in order to scarify seed coat and make it more permeable to water and gases.

Seeds can also be treated with chemicals such as sulphuric, nitric and hydrochloric acid in order to degrade the seed coat. Other compounds such as sodium hypochlorite and hydrogen peroxide have also been reported to scarify seeds (Hsiao and Quick 1984). Plant hormones like gibberellins, auxins and cytokinins are also effective in breaking exogenous seed dormancy.

Dormant seeds that are soaked in water may attain a moisture content close to 30%. Pre-soaking seeds to achieve the moisture content in this region can stimulate the breaking of dormancy (Roberts, 1982). Soaking seeds in water can also help to leach out chemical inhibitors present in seed coat which can induce seed dormancy.

Stratification can be given to dormant seed which is caused by embryonic factor. Stratified seed is preconditioned at temperature between 3°C to 10°C, but the specific temperature and duration of exposure may vary. In paddy seeds stratification, the seeds are exposed to temperature between 40°C to 50°C for several days. However, the seed moisture should not be exceeding 15% (Bhaskaran et al., 2005).

The rates of germination of many seed species can be increased by exposing them to daily alternating temperature cycles. Dormant seeds caused by endogenous dormancy can be broken by this method (Copeland and McDonald, 2001).

The germination of seeds with physiological dormancy can be affected by light intensity, wavelength and photoperiod. For some species like lettuce and birch, the seed dormancy can be broken by exposure to red-light (670 nm) (Copeland and McDonald, 2001).

Presence of chemical promoters for seed germination can break seed dormancy and induce germination. Hormones such as gibberellins, cytokinins, ethylene and auxins play an important role in promoting seed germination. In addition, chemicals such as hydrogen peroxide, potassium nitrate and thiourea have also been used to induce germination. Among these, potassium nitrate is the most widely used chemical
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