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Red rice

William Rufus Dodson

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WM. C. STUBBS, PH. D., Director and State Chemist.

RED RICE.

By W. R. DODSON, Botanist.

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J. G. LEE, COMMISSIONER.

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LOUISIANA STATE UNIVERSITY AND A. AND M. COLLEGE,
OFFICE OF EXPERIMENT STATIONS,
Baton Rouge, La.

Major J. G. Lee, Commissioner of Agriculture and Immigration, Baton Rouge, La.:

DEAR SIR—I hand you herewith results of careful investigations made for the last two or three years by the Department of Botany and Bacteriology of the State Experiment Station, under Prof. W. R. Dodson. These investigations were made at the instance of several rice planters in the State who have been greatly troubled with red rice in their crops, and Prof. Dodson's conclusions, from carefully conducted experiments and observation, are worthy of being embodied in bulletin form for distribution throughout the State, and I ask that you publish it as Bulletin No. 50.

Respectfully submitted,

WM. C. STUBBS, Director.

than the white. The grains are also smaller, and being lighter, they do not droop the supporting branches quite so much. The main branches of the panicle of the red rice are bent in a series of curves, the grain sitting on a very short peduncle, and the branch that continues above it curves around the grain; while the white grains are borne on rather long peduncles, the branch continuing almost straight, as the long peduncle puts the grain out of the way of the straight continuation of the direction of growth. These characters seem ample, in the judgment of the writer, to justify the classification of the red rice as a different variety, if not a different species from the white.

Other characters which will be discussed in connection with the habits of the plant, seem to strengthen this conclusion. The constant character of the small short grain of the typical red seed, is also noteworthy. The seeds that are partly red are intermediate in length and size between the typical red and the white, and later we will give evidence that this is due to a cross between the two, the cross partaking of the characters of both parent forms.

If the conclusion is correct that they are different species, the seed of one will not produce the other. This conclusion is directly at variance with the belief of most rice planters, who attribute the red grain to a physiological effect of physical conditions to which the parent seed has been exposed.

The belief seems to be almost universal, in this State, among rice planters, that when white rice seeds remain on the ground all winter, and grow the following spring, the seeds of that plant will be red. Many of them account for the origin of all the red rice in this way. They also believe that the red grain, when once started, will produce red seeds again, thus causing the increased amount from year to year. Others think an injury to the young plant will cause the seed to be red. They say if an animal bites off the rice stems when they are only a few inches high, the seeds will develop red. The last proposition will be passed over without serious consideration.

Still others say that tramping the ground will favor the development of red rice, and give as evidence of it that there is more red rice where the horses turn in plowing the land, and

sometimes more along the ditches than in the middle of the plot. It does frequently occur that red rice is more abundant near the ditches than elsewhere, but this may probably be accounted for from the fact that the water in the ditch may favor the development of a second crop, after the harvest, while the land interior would not present conditions so favorable after the planter ceased to give it attention. It is believed that this explanation is ample to meet the above proposition. The conditions that obtain in rice fields that are not flooded, has not been studied.

In regard to there being more red rice in the corners of the squares, nothing has been found to substantiate this theory, save where two ditches come together, and the occasional increased amount may be accounted for in the same way as above, that is, the water in late summer favored the ripening of seed in that locality more than elsewhere. These seeds remain over winter and increase the amount of red seeds the following year, while the white seeds that are matured in the same locality are mostly prevented from increasing the amount of volunteer white rice.

To test the validity of the planter's theory to account for red rice, we made some

EXPERIMENTS IN FALL PLANTING OF WHITE RICE.

Some experiments were made to test the effect of leaving the seeds exposed to the weather over winter. About a half pint of seeds were selected, the husk of each seed being cut with a knife, sufficient to see that the seed was entirely white, and that every red seed should be discarded, thus avoiding the possible confusion that might come from a single red seed if planted with the white. These seeds were disposed of in the following ways in the plots that were to serve for the summer growth the following year. Some seeds were covered with soil, some were left on the top of the ground and covered with straw, some were tied up in straw to keep them safely from mice and birds, and the whole package left on the ground. In February these latter seeds were covered with good soil. From this planting only a few seeds germinated, and a dozen or more plants were secured which stooled freely, and when

the heads ripened, they were found to contain, not red seeds, but white, not a single one being in the least colored. As these plots were carefully looked after, there could have been no seeds scattered there in the spring, and as the plants came in the rows where the seeds were planted, there is no doubt that the white seeds remained there all winter and produced white seeds the following year. Of the seeds that were planted in the fall, and covered with soil, as ordinarily planted, not a single plant developed in the spring. The same may be said of the ones that were left on top of the ground, though most of the seeds that were not protected, were destroyed by mice or birds. This experiment was practically duplicated in a plot that had contained rice the year before, but from which the seeds had not been gathered. There was possibly a half gallon of seeds left on the stems and on the ground, and from these, two plants came up in the spring, and these two plants bore white rice.

In September, '96, a bunch of white rice was tied up in a piece of cheese cloth and suspended from a limb of a shrub in the garden. It was fully exposed to rain and sunshine, and in the following spring the seeds were planted. From these seeds a fairly good number germinated, and were watched through their development. They all matured white seeds the following summer. A similar bunch of seeds was buried in the ground at the same time as above. In January the seeds were examined; it was found that many of them had sent up their tender stems above ground in the fall and had been killed, and most of the seeds were in a bad state of decay. Although these experiments were on a small scale, they at least demonstrate one thing, and that is that seeds do not produce red rice because of winter exposure in all cases. Further that there is no evidence that they do in any instance. We might also infer that the rice that remains suspended on the old stems is more apt to germinate in the spring than that which falls on the ground. That of the white rice that remains on the ground all winter, very little will germinate the following spring.

EXPERIMENTS WITH FALL PLANTING OF RED RICE.

The experiments above given with white rice were duplicated with red rice. The results may be summarized as follows: From the seeds that were planted in September many decayed. Of those placed on top of the ground and protected from mice and birds, a good number germinated. Of those that were protected in straw a large per cent. germinated the following spring. Of those planted in January a large per cent. germinated. In every instance the red rice exhibited a greater power of resistance than the white rice. When the seeds matured on these plants, all the grains on some of the heads, and some grains on all the heads were examined, and nothing but red grains were found. If the red rice is a variation from the white, we would expect to find some of the plants reverting to the parent form, in accordance with the laws of reversion in variation. But no evidence was obtained that any such reversion takes place, and this fact would strengthen the proposition that the red rice is a different species from the white and not a mere variation as a physiological expression of the effect of physical causes that have been operating upon the parent seed during the winter.

RESULTS FROM THE SPRING PLANTING.

The chief object in the following experiments, which were conducted at the botanical gardens at Baton Rouge, was to test the extent to which crossing would take place between the white and the red rice. Also the greatest distance at which two plants might cross. Ten rows, about 18 inches apart were sown in red rice. Adjacent to this plot ten rows of white rice were sown, the rows being the same distance apart. The seeds were carefully selected so that there would be no red seeds with the white, and no white with the red, when they were sown. When the harvest was made the husks of the seeds were removed that the seeds might be examined. The work was begun in the row of white seeds next to that of the red. In this row quite a number of seeds were found that had a red seed coat, and some that showed a tint of pink in the interior of the seed. In the second row fewer were found, and in no other row was any evidence found of the red

vation. This subject has not been satisfactorily demonstrated, however, and it is possible that they are mistaken. Notwithstanding their earnest and honest protest that no plants were allowed to seed, it is possible that some plants matured seed that escaped their observation. We have not been able to keep any seeds all summer in a moist soil. They either germinate or decay when the warm weather comes. But this is not the most important question, as we know that it can be soon exterminated from a field by thorough cultivation. The most important question is to prevent re-seeding. After the crop is harvested, and there is generally but one harvest a year, the stems that are cut often send out suckers of branches from the lower nodes, many of which will mature seeds before winter. This mode of reproduction takes place with the red rice as well as the white, but not to a greater extent, so there would be no greater proportional increase in the number of seeds, but as the winter approaches a remarkable difference in the provision for the

WINTER PRESERVATION OF SEEDS

is exhibited. From long cultivation the white rice has largely lost its power of self preservation, and a little warm weather after the seeds have matured, will cause a large per cent. of them to germinate, if sufficient moisture is available. If they are on the ground, the fall rains with the warm days that generally come in November and the early part of December, cause the seeds to germinate, and then they are killed by the winter's cold. On the other hand, the red rice is dependent upon self preservation for the continuation of its species, and under the same conditions as above stated, hardly a grain can be found that shows any evidence of germination. It is a law of nature that when a plant develops some character that makes it better suited to its surroundings, that character is apt to be maintained and developed in the offspring of that plant, but if the character is of no service to the plant, it is likely to be lost. Again, if a character is once acquired and the surroundings become changed so that the character is not brought into service for many generations, the character is apt to be lost. As the white rice is carefully harvested and stored in a

dry place over winter, it would have a tendency to lose the power that it once had of resisting the exposure of winter, while the red rice would be in its normal condition of remaining over winter without protection. In the following spring, of the seeds that had remained on the field, a large per cent. of the red rice would grow, and a small per cent. of the white rice would develop, and it is not hard to understand why the idea should become prevalent that all the seeds that developed were of the red variety, or that the white seeds had developed plants that bore red seeds.

But the red rice seeds are not alone dependent upon their power to resist premature germination or decay, but a more remarkable character is exhibited in preventing the seeds from being subjected to the moisture of the soil too soon. As will presently be explained, the seeds are more apt than the white seeds to be preserved in a dry condition, and this character, as much as any other, will account for the greater increase in the number of seeds.

The white stems generally decay at the nodes, in the late fall or early winter, and the upper part of the stem becomes separated from the lower, and the head of seeds falls prostrate to the ground. The stems of the red rice do not decay so readily at the nodes, but as the straw becomes over-ripe it weakens just above the first node below the head, or sometimes in the second internode, the head falls over and remains in a suspended position, possibly with only a few of the grains in actual contact with the ground. The head remains in this position, but many of the seeds become shattered off by the rain, by birds and by the wind, but many are preserved in this way in a dry state till all danger of fall germination is averted. In going over the fields in winter it is not a difficult matter to find the red rice, owing to this tendency of the heads to remain attached and suspended, rendering them more conspicuous. When these facts are taken into consideration it is not difficult to understand why a large amount of red rice should be carried over winter in condition to grow the following spring, and the consequent rapid increase in each succeeding year.

Again, some of the seeds that have not begun to grow at

surface exposed, we are almost justified in concluding at once that it is dependent upon catching pollen from the air. All plants will not cross, but nearly related ones often do. Now if a pistil of white rice should receive the pollen of red rice, and fertilization be consummated, the resulting grain will partake of the characters of both plants. In this way we believe the grains that are partly red are to be accounted for. If these seed are planted, the resulting plants will tend to become more and more like one or the other of the two parent forms, or to pass into a new variety, while a few of the forms would possibly remain the same. If the red rice is more hardy and stronger sexually, there would be a greater tendency to approach the red parent form, and especially if the flowers were to be fertilized by pollen from the red rice, thus having a tendency to increase the amount of that quality.

A CONSIDERATION OF THE BOTANICAL RELATIONS OF RED RICE.

Whether the red rice is one of the four species of rice described by books on botany has not been determined. It is not especially important to the planter to decide whether it ranks as a species or as a variety, just so it is one or the other and different from the white rice.

It is said that over 400 varieties have been exhibited in rice countries, and that among them are to be found varieties that present great variation in the color of the seed. Some have seeds that are yellow, some pink, some almost black, etc. These varieties have been obtained from occasional variations that have been noted by the cultivator, who has carefully and patiently selected seed to perfect a particular character in the course of a number of years. When plants normally reproduce seed, like the rice, and especially where cross fertilization takes place, variations often arise. A plant may be produced with some character or characters different from the parent form. When the seeds from this new plant develop, generally only a small per cent. retain the new character, but if these are again selected a greater per cent. of their offspring will preserve the character, until in the course of time this new character becomes well established. This is then called a new variety.

It would not be strange if there should occur an instance or a few instances where a red grain of rice was produced on a plant that came from a white seed, but it would be very extraordinary if a large number of such instances should occur at one time, or for a number of times in succession.

It would be still more extraordinary if other distinct characters should always accompany the color in the grain.

Such variations as might occur, arise from characters that are inherent in the plant. They come into existence independent of external conditions, but if that new character puts the plant organism in better sympathy with its surroundings, it is apt to be retained and further developed. If it is not serviceable in any way, it is liable to be lost unless man interferes to aid in maintaining it.

Some established laws relating to this subject can not be more compactly and clearly stated than to quote from Sach's Text Book of Botany, page 922:

"Those changes which are produced in a plant by the nature of its food and other external conditions must not be confounded with variation. Specimens of the same plant often differ conspicuously in the size and number of their leaves, shoots, flowers and fruits, according as their supply of food has been abundant or deficient; deep shade frequently occasions the most striking changes in the habit of plants that usually grow in sunshine; but these changes are not hereditary; the descendants of such individuals revert, under normal conditions of light and nutrition, to the original characters of the species.

"Those characters, on the contrary, which may become hereditary or form the ground work of varieties, arise independently of the direct influence of the soil, locality, climate, or other external influences; they appear seemingly without any cause. We must therefore assume either that external impulses, which are altogether imperceptible, first cause an imperceptible deviation in the process of development, which is always extremely complicated, and that this variation gradually increases until it becomes perceptible, or that the processes in the interior of the plant itself react upon one another

in such a manner as to cause sooner or later an external change.

"The fact that wild plants, when cultivated, usually begin to reproduce hereditary varieties, shows that the change in the external conditions of life, disturbs to a certain extent the ordinary process of development; but it does not show that particular external influences produce particular hereditary varieties corresponding to them; for under the same conditions of cultivation the most different varieties arise simultaneously or successively from the same parent form. The same is the case also in nature with wild plants; in the same locality under precisely the same vital conditions a number of varieties are often found by the side of their parent form, and the same variety is often found in the most diverse localities. It is for this very reason, because varieties are to so great an extent independent of external influences, that they are hereditary. A change produced in the plant by moisture, shade or any similar cause, is not hereditary, because its descendants, when placed under other vital conditions acquire again other non-permanent characters. That hereditary characters, or those that may become so, are not produced by external influences, is proved most conclusively by the fact that seeds from the same fruit produce different varieties, either exclusively or together with the hereditary parent form.

"Although the production of varieties and the form they assume are not the direct results of external influences, yet the continuance of the existence of a variety may be determined by these influences. When a variety is produced the question arises whether it will thrive best in damp or in dry ground, in sunny or shady places and so forth; whether it can reproduce itself under these circumstance, or whether it will die out. The conclusion follows that hereditary varieties arise independently of direct external influences, but that the continuance of their existence depends on external causes. A variety which occurs only in a particular locality is not produced by the condition of this particular locality; but it alone furnishes the peculiar condition of life which this particular variety requires, while other varieties which have arisen at the same place disappear."

Now if winter exposure of white rice seeds causes the offspring to take on all the characters that distinguish the red rice, it would be an instance in which every principle in the above deduction is violated. It would be an instance in which the physical conditions surrounding the plant not only changed its characters in a remarkable manner, but operating on the inactive seed bring about the changes long after the conditions have ceased to exist. It would be an instance in which very different conditions as to locality, moisture, severity of winter, and so forth, produce a definite and uniform variation, not once only, but thesame results year after year. Again, such a variation becoming at once definite, constant and hereditary, would indeed be such a remarkable fact that it could not be accepted without overwhelming evidence. As such evidence is not to be had, and strong indications to the contrary are obtained under careful experiment, we are obliged to reject the theory that white rice will be transformed into red by the mere exposure to the physical conditions of winter. Everything seems to be against the theory, little or nothing in favor of it.

After the red rice is once introduced into the field we can account for its increase, and the only reasonable explanation of its origin in the fields is that it was introduced there by impure seed.

REMEDY RECOMMENDED.

The following suggestions are made as possible means of reducing the amount of red rice and of preventing its recurrence. Two things are to be accomplished: Preventing red seeds from maturing in the field, and preventing them from occuring in the seed sown. Possibly the most important question is to prevent a second crop of seed from maturing after the general harvest. To this end it would possibly be a good plan to drain the land as soon as possible after the harvest and plow the stubble under. If it is then too late to sow cow peas, it may be sown a little later in some winter growing crop, if the ditches are kept open and the land well drained; some of the vetches, crimson clover, rape or anything that will give a good growth during the late fall and

winter. This crop may be pastured when the land is dry enough not to be injured, or the crop may be harvested and fed green, or it may be plowed under the following spring. When this can not be done, good may be accomplished by drying the land and placing cattle and hogs on it to destroy the grain that remains on the stems or is shattered on the ground. Hogs will pick up a great deal of the shattered rice. However, I do not know of anyone who practices this method.

Burning the stubble, a custom quite extensively practiced, will possibly destroy a good deal of red rice.

Plowing in the early spring and cultivation just before sowing may destroy many red rice plants.

If the land has once been entirely cleaned from the red rice by the cultivation of cane, corn or cotton, and absolutely clean seed are sown each year, no further difficulty should be experienced.

Careful attention should be given to raising rice seed for planting. If the seed are purchased, a guarantee should be demanded that the seed are free from red rice.

One can select a small quantity of seed from the field that he knows to be pure. Plant these on a piece of ground that he knows is absolutely free from red rice, and where no seeds can wash onto it, and make this a beginning of a special crop for seed. Every year afterwards he could sow a plot of land sufficiently large to furnish seed and devote special attention to keeping it clean.

CONCLUSIONS.

I. Red rice is a different variety from the white.

II. White rice will not produce red seeds when the seeds have been exposed to the weather all winter, as is commonly believed by planters.

III. The two varieties will cross, producing hybrids, and these hybrids tend to revert to one of the parent forms, the red rice being a little stronger.

IV. The red rice being dependent upon self preservation is hardier than the white rice, and also has a special device for preserving the seed from reaching the ground in early fall.

V. The proper methods to be adopted are to use clean

seed and prevent red rice from seeding after the general harvest.

RICE EXPERIMENTS—VARIETY TESTS.

In the early spring of 1896, seventeen varieties of rice were received from the Department of Agriculture. As none of them proved to be very highly successful, as cultivated in this climate, it will suffice to give the results with very brief comments. One thing was very noticeable in all the varieties, namely: the slow growth, and length of time required to mature fruit. In 1896 the seeds were sown about the middle of April, and only two varieties matured seed before frost. In '97, the seeds were sown the first week in March, with the following results. The names are given as written on the packages when received from the Department of Agriculture:

1. KALU WI, matured a fair crop of seed, which were harvested the first week in September.
2. MAHA ELWI, matured some seed the latter part of September.
3. SUDU HONARAWALA, matured only a few heads and many of the grains in these were not fully developed. The younger heads were killed by frost.
4. SUDUHATITI, grew to a height of about three and a half feet, but did not head out at all.
5. KALU HEENATA, was well headed and heavy grained November 15, but did not mature the seeds before they were frosted. The husks on the grain are almost black.
6. KALUHATITI, grew about two and a half feet high, but did not head out at all.
7. KALU KURU WA WI, grew about three feet high, but did not fruit at all.
8. KURAMAWI, grew about three feet high, but did not mature fruit.
9. SUDUHATITI No. 2, grew to be about three and a half or four feet high; was beginning to head a little when the frost came in November.
10. PUWAKMAL HATITI, a very poor growth and no heads.

11. KOTTIGARON, produced a fine crop of heads that were loaded with grain, but the grains were just in the milk when the frost stopped the growth entirely.
12. MALAWARIAN, was fairly well headed, but did not mature seeds.
13. MA WI, grew about three and a half feet high, but did not produce any heads.
14. KATTA MALLI, was just beginning to head out well the middle of November, and did not mature any seeds.
15. HAPU DEWARADDIRE, grew about three and a half feet high and was in blossom in November; did not mature seeds.
16. MADAL, heads nearly black, well formed, seeds barely matured before frost.
17. PALUKHAMBAM, did not produce any heads.

The plants were in the same soil and received the same treatment as plots of the common Louisiana rice, which matured.