

The dwarf plant habit - a breakthrough  
Now in the advancement of

Introduction of the Norin dwarfing  
genes in wheat breeding

yield in wheat  
and rice

.... D. N. S. Swaminathan  
Director, Indian Agricultural Research  
Institute  
New Delhi

It is now clear that fertilizer response is more a morphological than a physiological problem and that unless the plant has a morphological frame which enables it to resist lodging, the application of fertilizers and water in the quantities required for high yields is not possible. If the variety is not tailored to the needs of high fertility conditions, the yield may even tend to get depressed with the application of nitrogen doses exceeding about 40 Kgs N per hectare. A short, non-lodging habit is hence a pre-requisite for introducing a new agronomy capable of enhancing yields. Several dwarfing genes were known for a long time in wheat, such as the S or C loci which govern the Sphaerococcum and Compactum characteristics respectively. These loci, however, <sup>all</sup> had a pleiotropic effect on the ear, making it very dense and compact. The first variety which appeared to have the desired combination of short plant height, lodging resistance and kernel type <sup>the Japanese variety</sup> was Norin 10 (Vogel, C.A., Craddock, J.C., Muir, C.E., Everson, E.H. and C.R. Rohde, 1956, Agron. Jour. 48 :76-78). This variety was one of a collection of Japanese wheats brought to the United States by Dr. S.C. Salmon in 1948.

Using the Norin dwarfing genes, the dwarf winter wheat variety, Gaines, was developed by Dr. Vogel in the Washington State, United States. Spring wheat varieties had been developed in Mexico by Dr. N.E. Borlaug, using the Norin genes for dwarfing (three independent genes have so far been found).

In order to develop dwarf wheat varieties suitable for cultivation in India, the Indian Agricultural Research Institute, New Delhi, introduced in 1963 a large variety of wheat material containing the Norin dwarfing genes from Mexico through the courtesy

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of the Rockefeller Foundation and the Mexican Ministry of Agriculture (Swaminathan, M.S. 1965. IARI P.G.School Journ. 3 :57-62). In addition to breeding material, bulk quantities of four commercial Spring Wheat varieties - Lerma Rojo 64A, Sonora 63, Sonora 64 and Mayo 64 were also obtained. These varieties were tested in all the wheat growing States of India during the rabi seasons of 1963-64 and 1964-65 under the All-India Wheat Improvement Project. In addition, they have been subjected to detailed physiological, pathological, chemical and agronomic tests at the Indian Agricultural Research Institute. Two of these varieties, Lerma Rojo 64A, and Sonora 64 were approved by the Central Variety Release Committee of the Indian Council of Agricultural Research in 1965 for cultivation in irrigated areas.

Lerma Rojo is a late variety with a high degree of resistance to yellow rust. It performs very well under timely sown conditions and in areas characterised by yellow rust epidemics. Sonora 64, on the other hand, is an early variety and is well suited for being grown in rotations like maize-wheat, potato-wheat, rice-wheat, etc. It is the most lodging resistant variety so far developed. Being early, it is a safe variety for cultivation under high fertility conditions in the eastern part of U.P., Bihar, West Bengal, Rajasthan, Madhya Pradesh, Gujarat, Maharashtra and Orissa. Sonora 64 should not be sown before the middle of November in areas where the normal sowing time is late October or early November. It is susceptible to yellow rust and hence is not recommended for areas where yellow rust appears in an ~~epidemic~~ epidemic condition.

#### Characteristics of Lerma Rojo and Sonora 64

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Lodging resistance: Sonora 64 has two genes for dwarfing, while Lerma Rojo has ~~only~~ one such gene. As a consequence, Sonora 64 has a very high degree of resistance to lodging.

Growth Pattern: Detailed studies of growth and development in the dwarf wheats have shown that Sonora 64 produces only 6 to 8 tillers all of which come to maturity synchronously. Using a seed rate of 100 Kilograms per hectare and four to five irrigations, yields of five to six tons per hectare have been obtained. The synchronous tillering habit enables this variety to make an effective use of the fertilizer and water applied.

Biochemical characteristics: The protein and other quality characteristics have been studied in detail. On an average, the protein content of the grain was found during 1964-65 to be 14.6 percent. While Lerma Rojo is a soft wheat, Sonora 64 has strong gluten and has good chapatee-making qualities. When N is in abundant supply, irrigation during grain development does not lead to mottling of grains. The grains have a red colour.

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pre-sowing irrigation is given, there will be enough moisture in the upper strata of the soil and the seeds can be sown at a depth of two inches from the surface. Under such conditions, germination and tillering of Sonora 64 and Lerma Rojo are excellent. Irrigations prior to sowing and during grain development (February and March) are exceedingly important for realising the full yield potential of this variety. The maximum temperature during March at Delhi ranges from 29 to 32°C and at this time usually hot dry winds occur. While the normal varieties will lodge if an irrigation is given under such conditions, the dwarfs can be safely irrigated.

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Besides the selections made at the Indian Agricultural Research Institute, valuable selections were made at Ludhiana, Pant Nagar and Durgapura in the dwarf material sent to them. At Ludhiana, two selections PV.18 and S.227 have been found to do well. Selections for brown rust resistance have been made in S.227 at Pant Nagar.

Crosses between the dwarf wheat material from Mexico and promising Indian varieties were made in 1963 and several of the hybrid derivatives hold great promise for a further improvement of the yield potential and quality of wheat. Through induced mutations the grain colour of Sonora 64 and Lerma Rojo have been changed from red to amber. The quality and quantity of protein in these varieties have also been considerably improved (G. Varughese and M.S. Swaminathan, 1966, Curr. Sci. 35, No.18 : 469-470).

Nearly 400,000 hectares were sown with dwarf wheat varieties during the rabi season of 1966. Arrangements have been made to supply fertilizers in adequate quantities for this area and it is expected that the cultivation of such non-lodging varieties in conjunction with suitable agronomic practices would help to double India's wheat production within the next five years.

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Characteristics of Lerma Rojo and Sonora 64.

Disease resistance: Resistance to individual races of rusts was studied at the Division of Mycology and Plant Pathology of IARI and it has been found that Sonora 64 possesses resistance to 12 races each of black and brown rusts and four races of yellow rust. It is susceptible to loose smut and hence in seed farms the seeds should be treated against smut infection. Lerma Rojo is resistant to 8 races of black rust, 6 races of brown rust and 7 races of yellow rust.

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Yielding ability: The yield tests conducted during 1964-65 have confirmed the expectations these varieties raised during 1963-64. Lerma Rojo, because of its higher degree of yellow rust resistance has been found to do well in parts of Punjab and U.P., where yellow rust is a problem. Sonora 64 does very well in all areas where yellow rust is not a problem. At Delhi and Dohad (Gujarat), a yield of 6.4 tons per hectare was obtained with this variety during 1964-65.

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Crosses between the dwarf wheat material from Mexico and promising Indian varieties were made in 1963 and several of the hybrid derivatives hold great promise for a further improvement of the yield potential and quality of wheat. Through induced mutations the grain colour of Sonora 64 and Lerma Rojo have been changed from red to amber. The quality and quantity of protein in these varieties have also been considerably improved.

Nearly 400,000 hectares were sown with dwarf wheat varieties during the Rabi season of 1966. Arrangements have been made to supply fertilizers in adequate quantities for this area and it is expected that the cultivation of such non-lodging varieties in conjunction with suitable agronomic practices would help to double India's wheat production within the next five years.

Development of dwarf rice varieties: During 1964-65, 36.1 million hectares were under rice in India and the total production was 38.73 million tonnes. Out of the total area, nearly 13 million hectares have assured irrigation. An additional 1 ton per hectare can easily be produced in this area during 1967. A short and non-lodging variety is basic to getting the best out of fertilizer and water. Three of the chief limiting factors of yield in our irrigated rice growing regions are (a) the low response to nitrogen and other nutrients by the tall varieties (b) the restriction imposed by the lodging tendency on the supply of water during the advanced stages of grain development (c) the impossibility of adjusting the growing season in such a way that it synchronizes with natural lower temperature and sunny days which are conducive for efficient photosynthesis and good grain development. More than 30% increase in grain yield has been found by a change in planting time in some varieties. The monsoon season when rice is widely grown in India is unfortunately the most unsuitable for grain production. Even if high doses of fertilizers are applied, the reduced photosynthesis caused by cloudy skies limits their use by the plant, since carbohydrate reserves are essential for nitrogen use. The discovery of a dwarf, erect-leaf and photoinensitive type of rice in Taiwan called Dee-geo-woo-gen was hence an important landmark in the yield history of indica rices.

Tests conducted in different parts of the country have shown that both Taichung Native-1 and IR-8, which are dwarf and non-lodging varieties are capable of yielding 6 to 8 tonnes per hectare when grown under proper management. Many short-strawed, photoinensitive varieties will shortly be ready for release from the hybrids of adapted Indian varieties and Dee-gee-woo-gen, Taichung Native-1 and IR-8 already made in India. At the IARI, a dwarf Basmati variety of rice is currently under development. This would help to double the yield of the Basmati varieties now grown.

Powerful research tools are available which can help to rectify some of the prominent defects of the high yielding varieties like Taichung Native-1, Taichung-65 and Tainan-3. Through the treatment of seeds of these varieties with physical mutagens like X-rays and gamma rays and chemical mutagens like ethyl-methane-sulphonate, resistance to bacterial blight has been induced in Taichung Native-1. Similarly, non-sticky grains have been produced in Taichung-65. These new varieties, if cultivated with adequate fertilizers and pest and disease control, would help us to increase rice production by over 10 million tonnes during 1967.

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