CC/NUMBER 41
OCTOBER 14, 1985

This Week's Citation Classic®

Zadoks J C, Chang T T & Konzak C F. A decimal code for the growth stages of cereals. *Weed Res.* **14**:415-21, 1974. [Lab. Phytopathology, Agricultural Univ., Wageningen, Netherlands; Internatl Rice Res Inst., Los Baños, Lagunas, Philippines, Plant Breeding and Genetics Section FAO/IAEA, Div Atomic Energy in Food and Agriculture, Vienna, Austria; and Washington State Univ., Pullman, WA]

The paper describes an internationally acceptable scale for recording the development stages of cereals as they can be readily observed in the field. The scale covers all stages from seed to seed, using a two-digit, computer-compatible, easy-to-memorize, numerical code. [Cited in over 250 publications, this is the most-cited paper ever published in this journal.]

Jan C. Zadoks
Laboratory of Phytopathology
Agricultural University
6709 PD Wageningen
The Netherlands

August 21, 1985

Travelling through Europe's wheat fields (1956-1961) to study the epidemiology of yellow stripe rust (*Puccinia striiformis*),[1] I recorded growth stages—development stages we say now—in thousands of plots and fields using the somewhat clumsy Feekes scale.[2] I dreamt of a two-digit decimal code and of putting my data into that magic machine called the computer.

In 1966 I talked to a man able to implement dreams; S. Broekhuizen, scientific officer of the Netherlands Grain Centre, a sponsor of research in cereals that collected its money from wheat growers at a rate of one Dutch cent per hundred kilograms of wheat. He brought me and the third author, C.F. Konzak, a plant breeder on sabbatical leave with the International Atomic Energy Agency in Vienna, together at a meeting in Novi Sad, Yugoslavia, in 1966. Konzak also felt a need for an improved scale. He introduced more detail in the ripening phases, important to North American wheat growers. I added detail to the winter stages of fall-sown wheat, useful to cereal pathologists in northwest Europe. Years later, I learned about the value of detail in that early part of the wheat's life cycle for timing herbicide applications. Konzak proposed to contact the geneticist T.T. Chang from the International Rice Research Institute, who was engaged in similar efforts for rice. The three of us consulted many specialists and redesigned the scale at least 10 times in tedious correspondence. Receiving much good but contradictory advice, we felt frustrated near the end and almost gave up.

In 1973 F.G.H. Lupton, then president of the European Association for Research on Plant Breeding (Eucarpia), stepped in and pressed me to publish. The Decimal Code was first published in the *Eucarpia Bulletin*,[3] then in *Weed Research, Annual Wheat Newsletter*,[4] and *Cereal Rusts Bulletin*.[5] It was translated into Dutch, French, German, Portuguese, and Swedish. Large[6] illustrated the Feekes scale. I tried to provide new illustrations but was not satisfied. Excellent illustrations appeared in 1979.[7]

The Decimal Code was readily accepted, and it became the official standard for organisations such as the European and Mediterranean Plant Protection Organisation, the International Union for Biological Control, and the International Union for the Protection of New Varieties of Plants. As a plant pathologist, I am amused to see one of my nonphytopathological papers reach the citation top. The success of the Decimal Code, which is only one of several ways[8] to describe growth stages, I ascribe first to its timeliness and second to its being simple, field-oriented, computer-compatible, versatile, and easy to memorize. The Decimal Code has become a standard tool in all branches of agricultural science dealing with small-grain cereals—wheat, barley, rye, oats, and rice. For the present generation of scientists, the Decimal Code has become so obvious that some no longer cite it. Although a compliment, that result defeats the invitation to write this sketch.

1 **Zadoks J C.** Yellow rust, epidemiology and physiologic specialization. *Neth J Plant Pathol* 67 69-256, 1961 (Cited 55 times)
2 **Feekes W.** De tarwe en haar milieu (Wheat and its environment.) *Versl Techn Tarwe Comm* 12 523-888, 1941
3 **Zadoks J C, Chang T T & Konzak C F.** A decimal code for the growth stages of cereals. *Eucarpia Bull* 7, 1974. 11 p
4 ----------. A decimal code for the growth stages of cereals. *Cereal Rusts Bull* 3.14-23, 1975
5 ----------. A decimal code for the growth stages of cereals. *Annu Wheat Newsletter* 21 9-16, 1975
6 **Large E C.** Growth stages in cereals illustration of the Feekes scale. *Plant Pathol* 3 128-9, 1954 (Cited 395 times since 1955.)
7 **Tottman D R, Makepeace R J & Broad H.** An explanation of the decimal code for the growth stages of cereals, with illustrations. *Ann Appl Biol* 93 221-34, 1979
8 **Bauer A, Smika D & Black A.** Correlation of five wheat growth stage scales used in the great plains. *Micro-organism culture collections.* Peoria, IL: Agricultural Research Service, US Department of Agriculture, 1981. p. 1-17

