the microstructural details of the hilum.

Seeds of *V. mungo* and *V. radiata* were procured from G. B. Pant University of Agriculture and Technology, Pantnagar. Two or three randomly selected seeds were mounted on a brass stub and coated with a thin film (200Å) of gold in a JFC-1100 ion sputter coater. The coated specimens were examined in a JEOL-JSM-35C microscope at an accelerating potential of 15 kV. Photographs were taken using 120 mm film.

In *V. mungo*, the hilum is concave and ovate. Besides, a thick and raised rim is also present around the hilum (figure 1). The hilum of *V. radiata*, on the other hand, is flat and lanceolate without any rim. The hilar region is, however, demarcated from the testa by a narrow groove (figure 2).

With regard to the microstructural details, the hilar region of *V. mungo* revealed reticulo-tuberculated pattern, the tubercles being situated unevenly over the loosely knitted reticulae (figure 3). In case of *V. radiata*, the hilum was simply tuberculated without any reticulation. The tubercles were, however, larger than those of *V. mungo* and found scattered evenly throughout the hilar region (figure 4).

Based on the earlier SEM studies on seed coat structures in the species under investigation, many conclusions have been drawn. Sharma *et al.*[5] pointed out the role of surface characters in solving taxonomic and phylogenetic problems. Kumar and Rangaswamy[10] could report that the seed surface of *Vigna* was species-specific. Trivedi and Gupta[8,9], while studying the seed coat structures, concluded that the shape of the hilum was significant from the taxonomic point of view.

The present SEM studies are of taxonomic and phylogenetic utility. It may be concluded that *V. mungo* and *V. radiata*, having distinct hilum microstructures, are separate species. Besides, the presence of tubercles in the hilar region of both the species could suggest their origin from a common ancestral stalk—the view also shared by Zukovskij[11], Dana[12] and Jain and Mehra[1].

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MECHANISM OF LEAF ROLLING IN RICE

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LEAF rolling is one of the earliest visible physiological responses of plants to water deficit[1]. In rice (*Oryza sativa* L.) it begins at relatively high leaf water potential and progresses across a wide water potential range[2]. Although leaf rolling has often been explained as a means of reducing transpiration rate by plants experiencing water deficit[3], quantitative experimental data were provided only recently[4]. The mechanism of such drought-induced leaf rolling, however, has not been systematically studied. This communication provides information on leaf rolling initiation, progression and completion in response to field moisture stress in 100 genotypes of rice.

These rice genotypes, with a range of maturity duration, were grown under unirrigated rainfed upland conditions at the Crop Research Station (Masodha), Faizabad, during 1982 and 1983. Plants experienced moisture stress during dry spells that occurred at different growth stages. This allowed assessment of leaf rolling at vegetative, jointing, advanced reproductive and anthesis stages. The adaxial and abaxial surfaces of leaves were examined in the field and microscopically in the laboratory. A definite and precise variation in the smoothness of the leaf surface on either side of the midrib of adaxial and abaxial sides of leaves was noticed in all the genotypes. The leaf surface on one side of the midrib was smooth and on the other ridged and rough. These halves are referred to as 'smooth portion' and 'ridged portion' respectively (figure 1A). The ridged portion has many long and prominent strips running parallel to the midrib but the smooth portion has either no such prominent strips or has very few and rudimentary ones. The occurrence of smooth and ridged portions on leaves of a given plant was always phyllotaxically symmetrical. Whenever a leaf experienced water deficit the ridged portion bent first inward, followed by the smooth portion rolling over the former, resulting in a tubular shape of the leaf (figure 1B, transverse view).

Four types of leaf rolling initiation were identified in upland rices during field moisture stress. Rolling that originates at the tip and progresses towards the leaf base is common during vegetative to jointing stage when soil moisture stress develops slowly. Rolling of entire leaf also occurs, with ridged and smooth portions bending almost simultaneously; the time between initiation and completion of rolling is quite short. This type of leaf rolling occurs after jointing or during reproductive growth stages when moisture stress develops rather suddenly due to either water deficit in the soil or increased evaporative demand of the atmosphere or both. Helical rolling, often confined to the region from the tip to the middle of the leaf, and resulting in a twisted tubular shape occurs in the flag leaf during anthesis when stress develops rapidly. Further progression of helical rolling towards the leaf base gives rise to a non-helical shape on completion of rolling. This type of rolling is often observed in the flag leaf prior to anthesis when stress develops slowly.

The reason for the ridged portion rolling first, followed by the smooth one, might be differential loss in their turgor, i.e. turgor reduction occurs first in the ridged portion from the margin side, which is farther from the xylem vessels of the midrib, and slowly extends towards the midrib, and is followed by loss of turgor in the smooth portion, which then bends over the ridged one which has already rolled in. The reason for the lower turgor of the ridged portion is not known. However, it could be that the distribution of specialized bulliform cells (motor cells) is unequal, these cells being more in the ridged portion compared to the smooth, and this results in rapid water loss. Such a possibility may be arrived at from observations on differential rolling in sorghum and maize leaves reported by Martin[5]. Although the reasons for the existence of ridged and smooth leaf surfaces aiding leaf rolling during drought are not known, their identification in itself is an important and interesting observation from the standpoint of leaf rolling in rice.

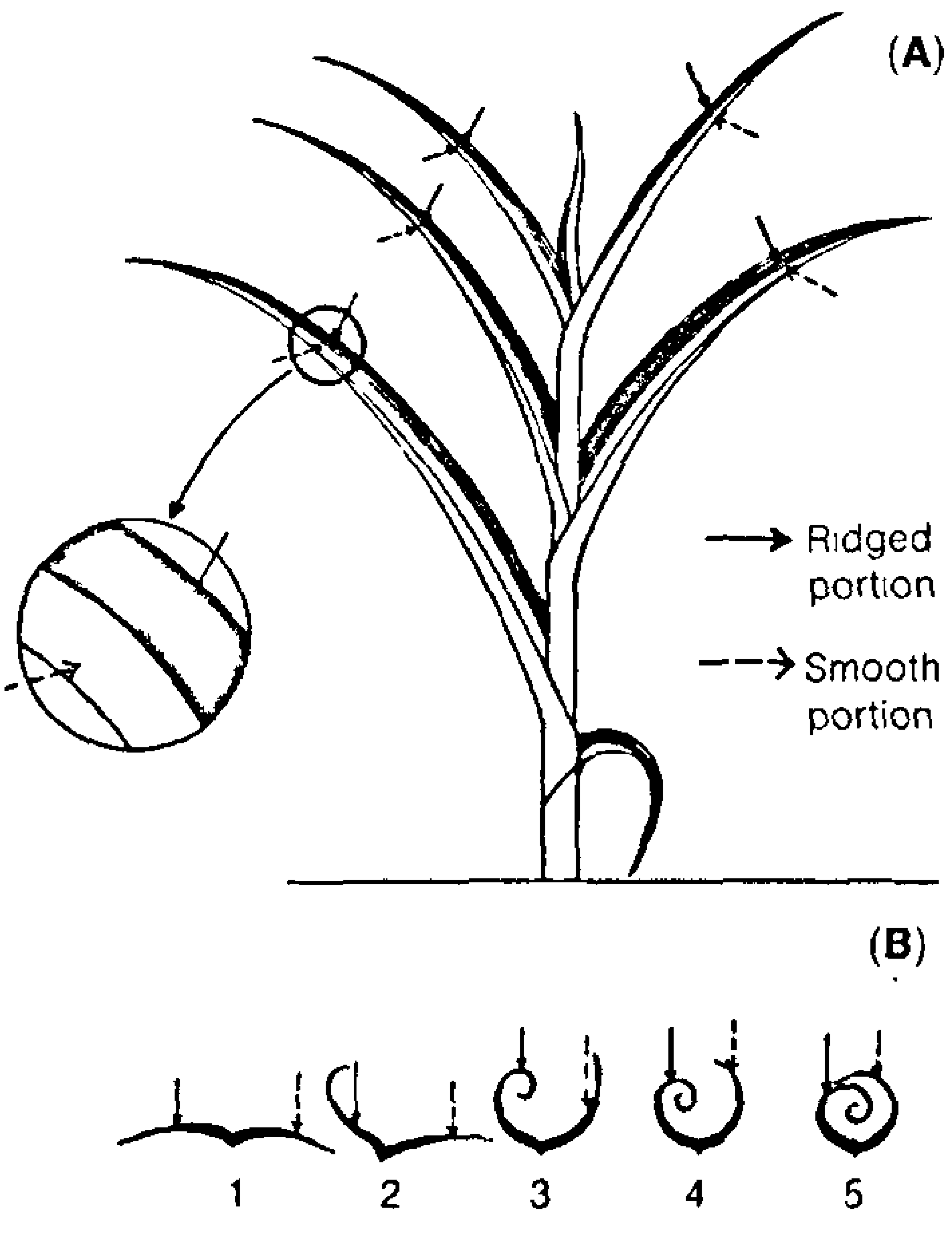

Figure 1. A, Ridged and smooth portions on rice leaves. B, Sequence of events in leaf rolling.

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RESIDUAL MERCURY ACCUMULATION IN EXPOSED MULBERRY PLANTS

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THE hazards of uncontrolled release of industrial and agricultural wastes have been clearly revealed by several serious incidents of mercury poisoning[1,2]. In each case the deaths were caused by consumption of food contaminated with high levels of mercury and pesticides incorporated through biological magnification in food chains. Considerable attention has been focused on mercury and mercury-based pesticides. Some of the mercury-based pesticides find use in mulberry cultivation. The literature on residual accumulation of mercury and its effects on mulberry plantation is scanty. The present work was undertaken to study the residual accumulation of mercury by the use of mercury-based pesticides and mercury-containing solid waste on mulberry plants.

A branch of mulberry (*Morus alba*) was cut into pieces 10 inches long. These were planted in different pots containing 6 kg manured soil (manure to soil 1:2). Care was taken to avoid flooding or drying of the pots. Pesticides and solid wastes were applied after the sprouting of 8–10 leaves on each mulberry cutting.

Solid waste of a chlor-alkali industry containing mercury was applied in one set of experiments. The solid waste contained 748.6 ± 32.3 mg of mercury/kg dry weight. Six concentrations were prepared, viz. 1.5, 3, 4.5, 6, 7.5 and 9%, and were applied in 6 pots at a time.

In the second set, $HgCl_2$ was applied. The application of the chemical was by two routes, i.e. application through the soil and by foliar spray. In one group of pots, $HgCl_2$ was applied through the soil and in another, $HgCl_2$ was applied by foliar spray. Three different concentrations of $HgCl_2$, viz. 0.02, 0.50 and 2 mg/l, were employed in each group.

In the third set, Emisan-6 at 1000, 2500 and 5000 mg/l was applied through the soil and by foliar spray. The concentrations selected were based on the studies of Mohapatra[3]. A set of control plants were maintained for comparison in each case.

Leaves from both control and treated plants were collected. The treated leaves were washed thoroughly to remove materials adhering to the waxy coat. A set of leaves was processed separately for dry weight determination.

Residual mercury was measured with a (cold vapour atomic absorption) mercury analyser using $HgCl_2$ (Analar) as the standard following the basic principle of Wanntrop and Dyfverman[4], which has undergone substantial modification in the light of recent developments[5]. The process of analysis has been described elsewhere[6].

Figure 1 shows residual concentrations of accumulated mercury (μg/g dry wt) in leaves after application of different concentrations of chlor-alkali solid waste, $HgCl_2$ and Emisan-6.

At lower doses of the solid waste there was a low amount of retention. With increase in solid waste concentration the residual mercury level showed a significant increase and at 9% the highest value (2.06 ± 0.32 μg/g dry weight) was recorded 30 days after exposure.

There were significant differences in residual concentrations between application of $HgCl_2$ by foliar spray and application through soil. The recorded residual level of Hg on leaves after foliar spray of 0.2 mg/l $HgCl_2$ was 120.16 ± 8.16 μg/g dry weight, and at 2 mg/l of $HgCl_2$, the residual Hg was 139.42 ± 18.42 μg/g dry weight. Soil application gave corresponding residual mercury levels on leaves of 3.7 ± 0.5 μg/g and 3.90 ± 0.33 μg/g dry weight.

In the case of Emisan-6 the differences in residual Hg levels between foliar spray and soil application were similar to those in the case of $HgCl_2$.

Control plants did not show any trace of mercury in the leaves.

It has been reported earlier[7–9] that mercury can be accumulated in different biotic systems to a dangerous level. Uptake and accumulation of chemicals may prove to be most important aspect of pollution dynamics. Since the leaves of the mulberry plant are the food of silkworm larvae, accumulation of mercury and pesticides in the leaves can cause damage to the sericulture industry. Larvae fed on contaminated leaves accumulate the pollutants within the body. Mercurial compounds are known to affect the growth and efficiency of animals[7,9]. It can be presumed that because of the drastic decline in growth and metabolism silk production by the