EPIDEMIOLOGI DAN PENGENDALIAN PENYAKIT KARAT KEDELAI
(Phakopsora pachyrhizi Syd.)

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EPIDEMIOLOGY AND CONTROL OF SOYBEAN RUST  
(Phakopsora pachyrhizi Syd.)

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ABSTRACT

Soybean rust, caused by \textit{P. pachyrhizi}, is one of the most serious legume diseases in Indonesia. Monthly observations of the disease symptoms were made at Pacet experiment farm (1100 m) in West Java. The rust lesions were light to dark brown or blackish and were mainly on the underside of the leaves. In earlier leaf stages, two types of disease symptoms were found: lesions with brown halo zones and lesion without haloes. It was presumed that these might indicate the presence of at least two races of the pathogen. The first type appeared to be more virulent than the second.

\textit{P. pachyrhizi} has several alternative hosts, most of which are wild or cultivated legumes. These include \textit{Calopogonium mucunoides}, \textit{Dolichos lablab}, \textit{Phaseolus lunatus}, and \textit{Vigna unguiculata}. The pathogenicity of the fungus on non-legumes (\textit{Artemisia vulgaris}, \textit{Bidens pilosus}, and \textit{Oxalis} sp.) and on legumes (\textit{Glycine max} and \textit{C. mucunoides}) were studied by artificial cross-inoculations of uredospores produced on each plant species. The spores from the non-legumes did not infect the two legume species, and similarly, spores from the legumes did not infect the non-legumes. The cross-inoculation tests showed that the spores produced on the two legumes were similar in pathogenicity. They were also similar in size, but were quite different from the
spores produced on the non-legumes. This suggests that the wild legume, *C. mucunoides*, may play an important role as the primary sources of rust infection of soybean in areas without previous soybean plantings. Eradication of this source is suggested for rust control.

Various possible methods of rust disease transmission were tested. Soybean seeds mixed uredospores of rust, seeds mixed with rust-infected soybean leaves, and seeds from rust-infected soybean plants were planted in separate pots. None of the plants grown from these seeds developed disease symptoms. This indicates that rust infection is not transmitted through seeds, and therefore must be primarily air-borne.

The sexual stage of *P. pachyrhizi* was microscopically examined on two soybean varieties: Ringgit (susceptible) and No. 29 (resistant to rust). No telia or teliospores were found in leaf tissues of either variety. It was concluded that asexual spores (uredospores) might be the most important source of soybean rust in the field.

Two methods of rating the intensity of rust disease were tested on three varieties (Ringgit, Orba, and No. 29) planted at Pacet at monthly intervals in 1982. The two rating methods were a modification of Mazzani & Hinojosa's method, and McKinney's method to use the International Working Group on Soybean Rust scoring system. Disease intensities were highly significantly
correlated among the varieties at the same time, and on plants of the same variety observed at 50, 60, and 70 days after planting. The two rating methods produced parallel disease intensity profiles, and either method can be used. However, the modification of Hinojosa and Mazzani's method is easier to apply.

Infection rates of soybean rust were calculated according to Van der Plank's formula, which can also be used for predicting rust epidemics. The various of measuring disease intensity and infection rates produced similar results.

Different rates of disease intensity or infection were observed on soybean planted at different times. The rates seemed to be influenced by abiotic environmental factors, especially the climatic factors. Partial regression analysis indicated that rust intensities at 50, 60, and 70 days after planting were strongly influenced by the maximum air temperature, solar radiation intensity, and rainfall. Other factor that also highly significantly influenced the rust intensity was the density of rust lesions at the first leaf stage. All or some of these parameters could thus be used for predicting rust epidemic. All these factors had a positive effect on rust intensity except solar radiation, which had a negative effect: higher solar radiation tended to lower the rust intensity rates.

In general, the disease intensity and rates of rust infection on Ringgit, Orba, and No. 29 varieties were lower in the dry season (May - September) than in the wet season (October - April)
The average rainfall in the wet season was about 210 mm per month (70 mm per 10 days), and in the dry season about 120 mm per month (around 50 mm per 10 days). It is suggested that rust control be carried out by planting soybean plants when the average 10-day rainfall is below 50 mm. The best planting time would therefore be in the early dry season (May) or in the early wet season (September). Planting in July and August would be hampered by the higher populations of seedling insects (Ophiomyia phaseoli) and drought (rainfall below 25 mm per 10 days).

Solar radiation intensities in the dry season were about 51-63 kcal per cm² per day; but in the early and late wet season, they were 68 and 40 kcal/cm²/day respectively. The same pattern was followed by the maximum air temperature, with over 26°C in the dry season and less than 24°C in the wet season.

The number of pustules per cm² on the first (lowest) leaf at one month after planting could be used to predict the future disease infection levels. If over 14 pustules per cm² are present on this leaf, the intensity of rust infection will subsequently be high. If less than 10 pustules per cm² are present, the disease intensity will be low. This monofoliolate leaf fell at about one-and-a-half months after planting.

The same soybean variety took different length of time to mature, depending on the planting date: each variety matured earlier in the dry season. The rust intensity on the susceptible (Ringgit) and on the resistant (No. 29) varieties was negatively
correlated with maturity. It seemed that the earlier the plants of a particular variety matured, the more susceptible they were to rust infection. There was also a tendency for later-maturing varieties to be more resistant to rust than early-maturing ones. Thus it would be more difficult for breeding programs to develop varieties with both early maturity and rust resistance.

Rust intensity affected the yield components of soybean. Partial regression analysis showed that rust intensity was highly significantly correlated to the percentage of defoliation: the more severe the disease, the heavier the defoliation. The percentage of defoliation could thus be used to estimate the intensity of infection.

Rust infection adversely affected the yield of soybean: the higher the intensity, the lower the yield. The effect of dust from the eruption of Mt. Galunggung in May - September 1982, and the high populations of seedling insects (O. phaseoli) in July - August also reduced yields.

At Citayam experiment farm (West Java) in the 1982 dry season applications of fertilizer in various combinations of N, P and K up to 90 kg/ha did not significantly affect the rust intensity, percentage defoliation, or yields of Orba variety.
The effect of rust on the yield and yield components of soybean was studied at Citayam in the 1982 dry season and 1982/83 wet season. The rust intensity was controlled artificially by applying various dosages of triadimefon fungicide at 0, 25, 35, 45, and 55 days after planting.

In the dry season, the fungicide application gave a negative linear regression with rust intensity and percentage defoliation. However, it had a quadratic relationship with yield. The optimum dosage of the fungicide was 0.3 kg a.i./ha (1.2 kg of the fungicide product, Bayleton), applied twice, at 25 and 35 days after planting. Triadimefon at such a dosage increased yields of Ringgit by 205 %, but of No. 29 by only 71 %. Application of the fungicide at the highest rate of 0.6 kg a.i./ha (2.4 kg of product) raised yields of Ringgit by only 108 %, and of No. 29 by 43 %, and reduced defoliation by 36 % and 33 % respectively. These reduced yields at higher dosages were suspected to be caused by the phytotoxic effects of triadimefon.

The wet season tests showed the same effect and trends as those in the dry season. At the highest rate of 1.0 kg a.i./ha (4 kg of product), the fungicide reduced rust intensity, percentage of defoliation and number of unfilled pods, and increased the number of filled pods and seed weight. The optimum dosage for Orba was 0.6 kg/ha, but was 1.0 kg a.i./ha for Ringgit and No. 29 varieties. Here, applications up to 1.0 kg a.i./ha were not toxic to the plants. It seems that leaching of the fungicide by rain-
water lowered its toxic effect. At this dosage, triadimefon increased yields of Ringgit by 730% over the control, but of No. 29 by only 100%. The average rust intensity at 70 days after planting was 48% on Ringgit and 35% on No. 29. Regression analysis showed that rust intensity was highly significantly correlated to the yield. The economic threshold (B/C ration = 1) could thus be calculated on the regression equation bases. It was found that this threshold was equivalent to a rust intensity at 50 days after planting of 39.6% on Ringgit, 41.2% on Orba, and 34.1% on No. 29. It is therefore profitable to spray triadimefon if the rust infection rates are above these intensities at 50 days.

The maximum yields obtained were 615 kg/ha for Ringgit, 692 kg/ha for Orba, and 822 kg/ha for No. 29 (water content = 15%). These yields were relatively low because of the dust from the Mt. Galunggung eruption. The maximum yield losses caused by rust were respectively 88%, 81%, and 50% for the three varieties, and defoliation rates were 76%, 64%, and 50% respectively.

Twenty-seven varieties of soybean were screened against soybean rust under field epidemic conditions at Muara and Pacet experiment farms in the 1979 dry and 1979/1980 wet seasons, and a further 23 varieties were tested at Cikeumeuh and Muara in the 1983 wet season. Five varieties showed stable resistance according to the International Working Group on Soybean Rust system: Petek, Mojosari, No. 29, No. 986, and No. 1682. All these varieties were late-maturing (90 - 100 days). It is suggested that
these varieties be planted to control rust epidemics in the field.

The genetic diversity of soybean could be increased by irradiation with gamma rays emitted by cobalt-60. Orba and Shakti varieties had earlier been irradiated with this isotope at their respective optimum rates of 22 and 25 krad. The M8 and M9 generation mutants resulting from this irradiation were screened for stable resistance to rust. This experiment was conducted at Darmaga experiment station in the wet and dry season from 1981 to 1983.

Some mutation characters were visible in the phenotype, such as the seed coat, stem hair and flower color, and the number of branches and the maturity. The seed coat of Shakti segregated to brown, black and the original cream, and seed sizes become bigger than normal. In Orba mutants, the hair turned from brown to white, and the flowers from violet to white. These mutants also increased their number of branches and their maturity period.

Under field conditions the Orba mutants showed more resistance and lower rates of infection than the original variety. However, Shakti mutants showed no significantly different reaction to rust. Among the original non-irradiated Shakti plants were a number of spontaneous mutants with larger seeds and higher yields. These mutants were promising; they included: 00(2)902-1-1; 00(2)902-2-2; 00(2)902-2-3; and 00(2)904-2-1. Some of the M8 and M9 of Shakti and Orba also showed higher yield potential, i.e., 22(2)813-1-7-3; 22(2)801-1-0-0 (from Shakti); 25(1)904-15-2; 25(1)904-25-3; 25(1)904-16-2; and 25(1)904-16-4 (from Orba).
UREDUM DAN UREDOSPORA

PHAKOPSORA PACHYRHIZI SYD.