Zero Cultivation and Other Methods of Reclaiming Pueraria Fallowed Land for Foodcrop Cultivation in the Forest Zone of Ghana

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SUMMARY

FOUR methods of dealing with *Pueraria phaseolodies* cover before planting the maize testcrop and their effect on crop-development and yields of this testcrop, were investigated. These methods were:

(*a*) removing the Pueraria cover followed by soil tillage,

(*b*) burning the Pueraria cover and incorporating the ash,

(*c*) slashing the Pueraria cover and incorporating the trash,

(*d*) "zero cultivation": spray-killing the Pueraria cover followed by planting the maize straight in the undisturbed, trash-covered soil.

These four methods were evaluated on basis of the practical problems involved in them and of their effect on crop-development and production of the maize. An effort is made to assess the role of the main factors involved in each of these methods: organic matter and mineral plant-food from the Pueraria cover, soil-cover provided by the Pueraria trash after the spraying and soil-tillage against non-disturbance.

The results point out the advantages of the "Zero cultivation" method: no tillage, no erosion and at least as good yields of maize as in the more conventional methods of burning or slashing followed by soil-tillage.

INTRODUCTION

The traditional system of foodcrop cultivation in the forest zone of Ghana is that of shifting-cultivation or land-rotation in which the soil's production capacity which is entirely based on the thin layer of organic topsoil, is in the long run maintained by alternating short periods of cropping with long periods of fallowing under the natural regrowth vegetation or bushfallow.

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This balance is more and more being disturbed by the growing population pressure on the land which leads to longer periods of occupation followed by too short periods for soil regeneration under bushfallow.

The revolutionising of food production by the introduction of the tractorplow to enable the farmer to cultivate larger acreages more intensively for the production of the required surplusses of food for the market, abrubtly confronts him with the problem of soil-fertility maintenance and regeneration.

The nature of the topography, the originally thin fertile topsoil and the chemically poor subsoil (Charter, 1955), the erratic character of the rainfall and the periodically severe dry seasons make an opening up of large areas for " modern mechanized land use " technically and economically highly problematic.

Degeneration of physical and balanced chemical soil-fertility under conditions of intensive monocropping, exposing the topsoil to the destructive forces of tropical sunshine and rainfall is bound to be much more rapid than under the peasant farming conditions of mixed cropping where the maize, cassava and banana covers overlap and gradually merge into the bushfallow regrowth.

Introduction of the tractorplow moreover abrubtly and finally excludes the possibility of relying on the free-of-charge, be it slow, regenation of soil-fertility by any natural regrowth-vegetation. Henceforth food-production depends on the artificial maintenance or periodic restoring of topsoil-fertility, both physical and chemical, within an economic system of permanent land-use.

The Arable Crops Section of the Faculty of Agriculture of the University of Science and Technology at Kumasi, therefore started work in 1957 on the development of ley-pastures and foddercrops for their inclusion in crop-rotations in a mixed farming system. This was done in the expectation that in teamwork solutions could be found for the keeping of cattle in this part of the country where the climatical conditions are the most suitable for foragecrop cultivation but where the tsetse fly borne trypanosomiasis disease threatens the animals.

One of the most promising legumes, on the grounds that, once established it maintains a dense and green cover throughout the year and has good livestock feed value, was found to be *Pueraria phaseoloides or--javanica,* the so called tropical kudzu. This crop was also expected to have a value for rapid intensive soil-regeneration.

One of the main questions connected with the use of Pueraria was: once we have grown it for a length of time, how should we bring such Pueraria covered land back into cultivation to derive the maximum benefit both in the sense of direct crop-production and of long-term soil-conservation.

Having at our disposal a well established 3 years old Pueraria cover, it was this aspect we have tackled in the experiments during 1961 and 1962.

ENVIRONMENT

Location : The farm is situated 6 miles East of Kumasi, just South of the Kumasi-Accra highway, in the forest zone, at an altitude of about 800' above sealevel.

Land : The land had been cleared in 1954 from the natural regrowth vegetation of bush and occasional tall trees, left behind by the local population after intensive land-use for foodcropping on a shifting cultivation basis which destroyed the original climax vegetation of semi-deciduous rainforest.

Soil : (Crosbie, 1954) The soil has been formed over crystalline rock of acid intrusions of the Cape Coast Granite complex; on the farm this is mainly pegmatitic granite and granodiorite consisting of quartz, felspar, biotite and muscovite.

Drainage is generally good. Topsoils consist mainly of light clay or sandy loam, moderately acid in reaction, with smaller or greater amounts of quartz gravel. Subsoils are yellow, reddish to brownish compact gritty loams with flakes of biotite or muscovite, acid to very acid in reaction, intensively and deeply weathered.

Available plantfood sharply decreases below the thin layer of the organic matter-rich topsoil, which is typical for the forest soils (Charter, 1955).

Climate : (Walker, 1962) Monthly average temperature maxima are highest for March : 91° F, lowest monthly average minimum is for January : 67° F. The total annual rainfall of beween 45″ and 65″ is distributed over a major rainy season from February to July and a minor rainy season from September to November.

The major dry season from November to February is usually very dry with intermittant periods of " harmattan ", the dry dust-laden Sahara wind, whereas the minor dry season from July-September may be humid with much cool and dull weather.

Rain often falls in heavy showers accompanied by strong winds which bring with them the dangers of severe erosion and crop-damage.

THE 1961 EXPERIMENT

This was the first orientation into the problems and possibilities of the four methods of Pueraria-reclamation, during the February-July season. The methods *a* (removing), *b* (burning) and *d* (spraying) were each compared with method c (slashing) in adjoining 1/40 acre plots (see fig. 1 B).

Procedure

Operations : Removing the Pueraria cover (*a*) down to the mineral soil was done by rolling up the cover after cutlassing at groundlevel ; burning the Pueraria cover (*b*) was done without previous cutting ; slashing the Pueraria cover (*c*) was done with the Lillistone rotary slasher ; spraying was done 20 days before planting the maize, with Shell 50 (2.4-D) at 4 pts. per acre in 80 gallons of water ; plowing of *a*, *b* and c plots was done with the Ferguson 2-disc plow, harrowing followed with the offset discharrow ; planting the maize was done by hand : 3′ between rows, 2′between plantholes in the row and 3 seeds per hole of Fernosan treated seed ; filling vacancies was done one week after the planting, supplying 2 seeds where one seedling had emerged and 3 seeds where none had emerged ; thinning down to 2 plants per stand or planthole was done 2 weeks after the filling.

Measurements:

Pueraria-cover and soil: Samples were taken but could not be analysed due to lack of laboratory facilities.

Maize-growth : Plantheight measurements were taken at 3 stages during crop-development : 30, 45 (start of taseling) and 60 days (tasseling complete) after planting.

N. B.—The first two measurements were taken up to the funnel, the last one to the tip of the tassel. Only the largest plant per planthole was recorded.

Maize yield : Harvesting was done after removal of broad strips on the plot-outsides, leaving about 150 stands per plot. Since animal damage was practically nil, all these stands were harvested and counted per plot for calculation of the yield per 100 stands (plant holes) from the weight of the dry grain and the corresponding number of stands.

Observations : The Pueraria cover at the start of the trial consisted of a relatively thin layer of green foliage over a dense mass of decaying foliage and vines carrying numerous fine roots at their nodes, closely integrated with the topsoil and the great numbers of wormcasts on its surface. The whole mat was anchored by fleshy rootstubs.

(*a*) Removing the Pueraria cover is no practical proposition but was done to provide a basis for comparison to assess the value of the Pueraria mass in terms of organic matter, mineral plantfood and soil-cover in the other treatments.

There was no problem of Pueraria regrowth in the maizecrop from either seed or vines, but erosion was a problem.

(*b*) Burning at the end of the dry season before the first rains, was complete. There was no trouble with tough vines during plowing, nor with regrowth in the maize-crop. Erosion was a problem however.

(*c*) Slashing followed by plowing involved so many difficulties in dealing with the loose trash and tough vines, that in its present form it is not a practical proposition. There was some more weedtrouble from sprouting of insufficiently burried vines ; erosion was as under *a* and *b*!

(*d*) Spraying resulted in a very compact layer of seemingly dead material close to the ground, which provided good weedcontrol and complete erosion-control. Some regrowth of the Pueraria necessitated one quick cutlassing through the maize crop.

Maize plants on the d-plot stood up remarkably better to fierce rainstorms with heavy gusts of wind than those under the other treatments where heavy lodging occurred.

The planting of maize in d-plots involved the punching of holes with a stick through the trashcover followed by rather perfunctuary covering of the seed after dibbling. The soil here proved more solid than expected and some force was needed to make the plantholes. Mechanizing this phase would need some consideration and adaptation of machinery.

Results :

Pueraria cover : The amounts of fresh material represented by the Pueraria-cover calculated from the 1′ × 1′ samples were:

At the start of the experiment: from 10.5 to 12 tons per acre.

19 weeks later: from 3.5 to 4.5 tons per acre.

Maize-growth : Results of measurements are given in fig. 1 A, comparing the plantheight-averages for treatments *a*, *b* and *d* with that for the *c* treatment. In order to eliminate the influence of soil-differences, plantheight and yieldfigures for *b* and *d* have been adjusted by the ratios $\frac{c\,1}{c\,2}$ and $\frac{c\,1}{c\,3}$ respectively.

Maize-yields : Results are shown in fig. 1 B, in the same manner as for maize-growth.

N. B.—Though it is not usual to connect the points for *a*, *b* and *d* as done in fig. 1 A and 1 B, this was yet done to bring out the changing pattern of growth of one treatment in relation to the other and also to show the similarity in trends for growth and yield in 1961 and 1962.

5—H 12385 (3/68)

Results from this experiment seemed to justify a repetition on a more scientific basis, which was done in the following year.

THE 1962 EXPERIMENT

This experiment was layed out as a randomised blocks trial with the four treatments replicated over six blocks. In order to eliminate as much as possible the influence of systematic soil-differences within blocks, the blocks were projected in the field in such a way that each fell amply within the soil-series indicated by the detailed soil-survey (Crosbey, 1954).

Each treatment-plot consisted of 4 rows of 65′ length; between treatments and on block-outsides two guardrows were planted for discarding at harvesting.

Procedure

Operations : Removing, burning and slashing were done as in 1961. Spraying was done with Weedone 32 brushkiller, an Anchem product based on 2.4-D and 2.4.5-T, at the rate of 6 pints of Brushkiller in 45 gallons of water to the acre.

Plowing and harrowing was done as in 1961; the scalloped discplow which was to be used for the dealing with the trashcover under treatment *c* (incorporating the slashed cover) did not become available.

Ridging on *a, b* and *c* treatment-plots was done for erosion-control with the Ferguson mouldboard ridger at 3′ between ridge-tops, 40 days after the plowing.

Plant-line cutting on d-plots was done with the disccoulter of a Ferguson subsoiler to which two small wings were attached to push the trash aside over 6″ to facilitate planting.

Planting was done by hand on *a, b* and *c*-plots in the ridges and on *d*-plots in the cleared plantlines between the dead Pueraria-cover. Planting distances, number of seeds per hole and seedtreatment were as in 1961.

Filling and thinning were done as in 1961.

Measurements

Pueraria-cover : The total mass of Pueraria-cover on each of the roughly 1/40 acre plots was weighed at removal.

Moreover one foot square samples were taken in the lanes between treatment-plots in all blocks at the rate of 3 per block, down to the mineral soil for weighing and dry matter determination and analysis at the Faculty soil chemistry laboratory.

Soil : Sampling was done after the first harrowing: 5 samples per plot to 6″ depth, compounded into one per plot. Analyses was done at the Soil and Landuse laboratories at Kwadaso.

Soil moisture : Tensiometer readings were taken with the Gallenkamp porous pot tensiometers for checking up on the influence of treatments on the soil-moisture situation. One of these was installed in each of the four treatment plots of block B: pot-centres 6″ under the soil surface (ridge-tops for a, b and c plots) in plantlines. Due to the late arrival of the equipment readings could not commence before May ; they were taken as much as possible at 7.30 and 14.30 hours daily.

Maize-growth : Plantheight measurements to compare growth-rates under the different treatments were done twice during the development of the maize crop: 40 days after planting (start of tasseling) and at 65 days after planting (completion of tasseling). On both dates 30 stands (highest plant per stand) per plot were measured; first measurement was up to the leaf-funnel, the second up to the highest leaf axle !

Maize-yield : In view of the rather heavy animal damage, only those stands with undamaged cobs on both plants, were harvested and counted. Stands in which one or both plants just failed to produce a cob were also counted as harvested stand however.

Yields were thereupon calculated from the weight of the dry (14% moisture) grain and the number of harvested stands per plot and expressed again as lbs of grain per 100 stands. This procedure was followed to exclude the disturbing influence of the damage by ground-squirrels, weaverbirds, etc., and to obtain a fair basis for comparison.

To investigate a possible preference by animals for a specific treatment, a statistical analysis was made for the number of undamaged stands per plot.

Observations

(*a*) Removing: The ridging did not keep erosion in check; on the contrary, during heavy concentrated rains the ridges conducted the water to the lowest places where the water then broke through whole series of ridges down the slope. Extensive tie-ridging by hand thereafter gave good control.

(*b*) Burning : as in 1961 ; erosion problem as under (*a*)

(*c*) Slashing : as in 1961 ; erosion problem as under (*b*)

The ridging on these plots where a lot of trash had been buried 40 days previously, did not meet any difficulties, which confirms our earlier experience that burried plant material rapidly desintegrates during the rainy season.

There was little Pueraria regrowth.

(*d*) *Spray-killing* : the brushkiller treatment was only little more effective than the 2.4-D spraying in 1961. The plantline-cutting gave much Pueraria seed and especially in blocks E and F much grass seed (Pennisetum pedicillatum and Rottboellia exaltata) a chance to germinate and create a serious weedproblem in these plantlines (photo 1). The unbroken cover of dead Pueraria in 1961 gave a far better weed suppression. Pueraria growth was once cutlassed and further regrowth was regarded favourable for the formation of a new soilcover to follow the maizecrop. Erosion under this treatment was again completely controlled.

Crop-development :

Filling.—at the time of filling of vacancies, one week after planting, the interesting observation was made that on *a*, *b* and *c* plots many of the seedlings were very yellow in the heart and several badly stunted. Where seedlings were missing, they were usually found in the soil, completely distorted and yellow, unable to break through the thick hard crust which had formed on the ridges as a result of the heavy rainfall during the previous days (.48, 1.20 and 2.75″) on the unprotected ridge-tops. Seedlings on d-plots did not suffer in this respect and were remarkably greener and taller in comparison.

Thinning.—at the time of thinning, two weeks after filling, great differences in plant-development between treatments could already be seen (photo 2). In all blocks the d-plots showed far superior plant-development practically without discolorations, c-plots showed a more irregular stand and some purpling of bottom-leaves, the maize crop on b-plots was irregular in most blocks with several thin, dwarfed plants with purpling bottom leaves. The a-plots showed poor to very poor crops in all blocks : thin, dwarfed plants with hardly any stem yet, with yellow, purple and bronze discoloration and bottom-leaves often drying up from the tip inwards.

Plant-growth in following weeks is clearly shown in the results of plantheight measurements which bear out the great differences in development between treatments.

The observation of 1961 that plants on d-plots were more resistant to lodging, was confirmed in 1962.

RESULTS :

Pueraria-cover.—the amount of organic matter above soil, calculated from the 1′ × 1′ samples were for the 18 samples, in tons per acre :

	Max.	*Min.*	*Average*
Fresh material	19·1	9·9	14·7
Ovendry material	7·6	4·7	6·2

The amounts of fresh material calculated from the amounts removed from the a-plots were in the order of 10 tons per acre ; this material was however much drier than the fresh material of the 1′ × 1′ samples due to 48 hours of hot and dry weather between these samplings. Unfortunately no dry matter determination could be made due to oven-failure.

Pueraria analysis.—the mineral content of the Pueraria cover, determined by analysis of the 1′ × 1′ samples is given in table 1, which also gives the amounts of N, P, K and Ca, calculated on basis of the 6.2 tons of dry Pueraria matter per acre.

For comparison figures for the immobilization of minerals determined in the Congo (Laudelot, 1962) and the mineral content of Pueraria grown on a lateritic soil in Suriname (Dirven and Ehrendron, 1963) are quoted.

Soil-analysis : results are given in table 2. Variation within treatments was rather great and none of the differences found between treatments reached statistical significance for P=0.05.

Soil moisture : fluctuations in soil-moisture tension (cm Hg) for a, b, c and d-plots of block B are shown in fig 2.

The graphs cover the two periods over which continuous readings were available and during which great variations in rainfall occurred (see rainfall distribution graph in fig 3). The graphs represent morning readings only ; high readings correspond to low soil-moisture contents and vice versa.

Since rains practically always fell during the evening, the afternoon readings were nearly always higher than the morning readings. The differences between morning and afternoon- readings for the 38 days over which both afternoon-and morning-readings were taken, when added, give the following totals :

a plot : 78   b plot : 93   c plot : 71   *d plot : 30*

The unfortunately only soil-moisture determination made before oven-breakdown, seems to confirm this trend :

a plot :	10·3%	*b* plot :	9·2%
c plot :	10·9%	*d* plot :	12·7%

The samples were taken near the tensiometers in the plantrows.

Maize growth : results of plantheight-measurements are given in fig. 4A. The graphs illustrate the similarity in trend between the 1961 and the 1962 results.

Results of the statistical analysis are given in the table 3.

Undamaged stands : differences between treatments in the numbers of undamaged stands per plot were found to be statistically insignificant, for P=0.05, indicating that there was no preference by the animals for a particular treatment.

Maize yields : the yield figures expressed as lbs of grain with 14 % moisture content per 100 undamaged stands, are given in table 4, which also shows the statistical analysis of the results.

DISCUSSION

When we compare our soil-analysis figures with those for a representative ochrosoil under Cocoa (Charter, 1955) and with analysis figures quoted for Ghana forest soils (Nye and Stephens, 1961) then we must qualify our soils as definitely poor : pH and O.M. are rather low, Cation Exchange capacity is low and Ca and K contents are very low. Our soils are apparently considerably impoverised during former occupation, whereas the 3 years of fallow under Pueraria have clearly not regenerated soil-fertility to a satisfactory level.

The quantities of minerals locked up in the Pueraria cover, when compared with those for Pueraria grown elsewhere are also relatively small. According to Dirven and Ehrencron (1963) the percentages of N and K are even critically low for normal growth of the Pueraria.

To decide if the topsoil has really gained in chemical fertility either from the subsoil or from the atmosphere (N) via the Pueraria cover during the fallow period, we would need the figures of the topsoil analysis from before the fallow-period which were unfortunately not available.

The fact that the maize crop under treatment b (burning and incorporating the ash) highly significantly outgrew and outyielded that under treatment a (Pueraria-cover removed) shows that the minerals (mainly K and Ca since most of the N must have been lost with the burning) in the ash had a positive effect. That is if we may ignore a possible effect of the burning on the soil.

It is remarkable that the differences in growth rate and yield between treatment c (all organic material incorporated) and b (all organic material burned and loss of most of the N) failed to reach significance. This means that the addition of the organic matter component and the Nitrogen contained in the above-soil Pueraria mass had little effect ; from this it would seem likely that the level of the other elements was still the main limiting factor for crop-performance. Results in the next year when NPK fertilizer-application was introduced in splitplots of the a, b, c and d treatment plots (Kannegieter, 1963), strengthen this conclusion (see photo 3).

A positive effect of the Pueraria fallow on the soil-structure did not show up in a particular looseness of the topsoil which was on the contrary very compact at the time of planting the maize on d-plots.

Differences in height-growth and yield of the maize between treatment d (zero tillage) and c (slash and incorporate) or b (burn and incorporate) were also statistically insignificant.

We may surmise that most of the nutrients contained in the dead Pueraria litter were rapidly released to the underlying soil during the growth of the maize-crop (Nye and Greenland, 1960) just as the rapid desintegration of the Pueraria mass under treatment b (in the soil) would have done. Figures for the amounts of litter before and after the experiment however indicate that under treatment d a good amount of the organic matter has been lost during disintegration of the litter on the soil.

Soil-moisture readings in fig. 2 clearly demonstrate that the undisturbed soil under the dead Pueraria cover of treatment d dried out much more slowly than in the unprotected ridges of a, b and c treatments. Long before the tension in d reaches its maximum in May and in July, tensions for a, b and c have already reached values where the gauges stop functioning and have to be refilled with water. This refilling was not done forthwith at the end of May, otherwise the graphs would have dropped again with the new rainfall of May 26.

In July reactions of d to drought are more rapid, probably due to a greater intake by the crop and a disappearance of the litter-cover, but they are still considerably slower than those for a, b and c where moisture losses were apparently far more severe before the new rainfall of August 1. In August when the drought really sets in, the graph for d follows a, b and c more closely.

Nevertheless this soil-moisture stabilizing influence of treatment d has not resulted in significant gains either in height growth or in yield of the maize even though it showed up in a better resistance of the maturing crop to lodging compared with other treatments.

However, the zero tillage method of spraykilling the Pueraria cover and planting the maize without prior tillage into the litter-covered soil combines two advantages :

1. it saves us the tillage operations.
2. it provides ideal protection of the soil during the critical period of establishment and much of the further development of the foodcrop. Especially the crust-prevention by the litter-cover under treatment d should be seen as an important advantage of this treatment. This crust formation killed many of the seedlings in the other treatments, but the extensive filling of vacancies eliminated the undoubtedly significant influence this would have had on the yield pattern !

   The Pueraria litter during cropping periods and its regrowth between cropping seasons maintains a continuous soil-cover which successfully suppresses weedgrowth and prevents soil-degeneration in the physical sense. The next logical step is the introduction of using chemical fertilizer to improve and maintain the chemical soil-fertility at an optimal level for crop-production.

CONCLUSION

The zero cultivation method of bringing back a Pueraria covered land into cultivation, consisting of spray-killing the Pueraria vegetation and planting the foodcrop (in the experiment : maize) into the undisturbed and litter covered soil, was found to have advantages over the more conventional methods of burning or pulverising the vegetation followed by incorporating the ash or trash into the topsoil by discplowing.

Whereas the yields of maize were in the experiments found to be at least as good as those obtained under the conventional treatments, the zero cultivation method saves us the need for plowing and harrowing and extensive erosion-control measures.

The soil-protective cover formed by the sprayed Pueraria extends far into the cropping period, preventing crust formation at the critical time of seedling emergence, suppressing weedgrowth and maintaining more favourable moisture conditions in the soil.

The crust prevention obviates the need for extensive filling of vacancies in the seedling crop, which is necessary under the conventional methods.

The application of the Pueraria as a soil-cover in combination with the zero cultivation method of reclamation and crop-establishment would seem well suited for the transition stage between the original shifting cultivation and the ultimate permanent land use as well as for incorporation in a rotation for permanent land use itself.

Instead of leaving his old clearing to revert to bush, the peasant farmer could sow Pueraria to mothball the area and suppress the natural vegetation regrowth. This in combination with the spraying would make reopening the area for renewed cultivation much easier and enable the farmer to cultivate larger units of land without much extra investment : the only equipment needed is the knapsack sprayer to apply the weedicide.

The Pueraria fallow/soil-cover, especially when supported in its development and supplemented in its action by fertilizer application would then go far in keeping up the overall production capacity of the soil under the more intensive land use.

If large scale mechanized foodcrop cultivation is the aim, this approach could be used during the reclamation stage to let the tree-stumps desintegrate in their own time while the soil in between is being handcropped, thus obviating the great expense and topsoil damage of mechanical stumping and rooting. Admittedly this would mean giving up the short term policy of revolutionizing farming methods (political land use) in favour of the more long term approach of evolutionizing farming methods (scientific land use).

If the problem of mechanizing crop-planting into the litter covered and untilled soil can be satisfactorily solved, the use of Pueraria as a temporary fallow (cum fodder-source for cattle) combined with the zero-tillage method and fertilizer-application could well become an integral part of the mechanized crop rotation.

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Photo 1—Weedgrowth in bare plantlines between dead Pueraria cover of the d-treatment

Photo 2—Cropdevelopment : the white-tipped and the black-tipped stakes mark the guardrow between treatment *b* (left) and *a* (right).

Photo 3—Effect of NPK application : behind the man in the picture no fertilizer applied, in front NPK applied.

Fig. 1A Treatment means for plantheight (1961)

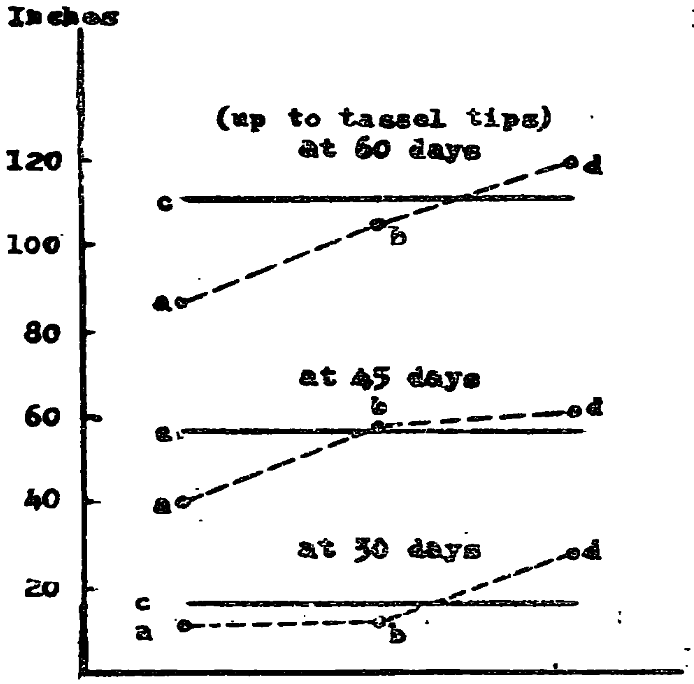
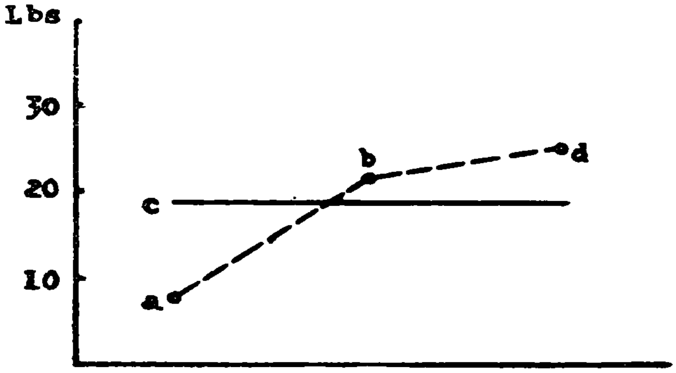


Fig. 1B Grain yields (14% moisture) for 100 stands per treatment (1961)



Plot arrangement

c 1	c 2	c 3
a	b	d

Fig. 2 Soil Moisture Tension

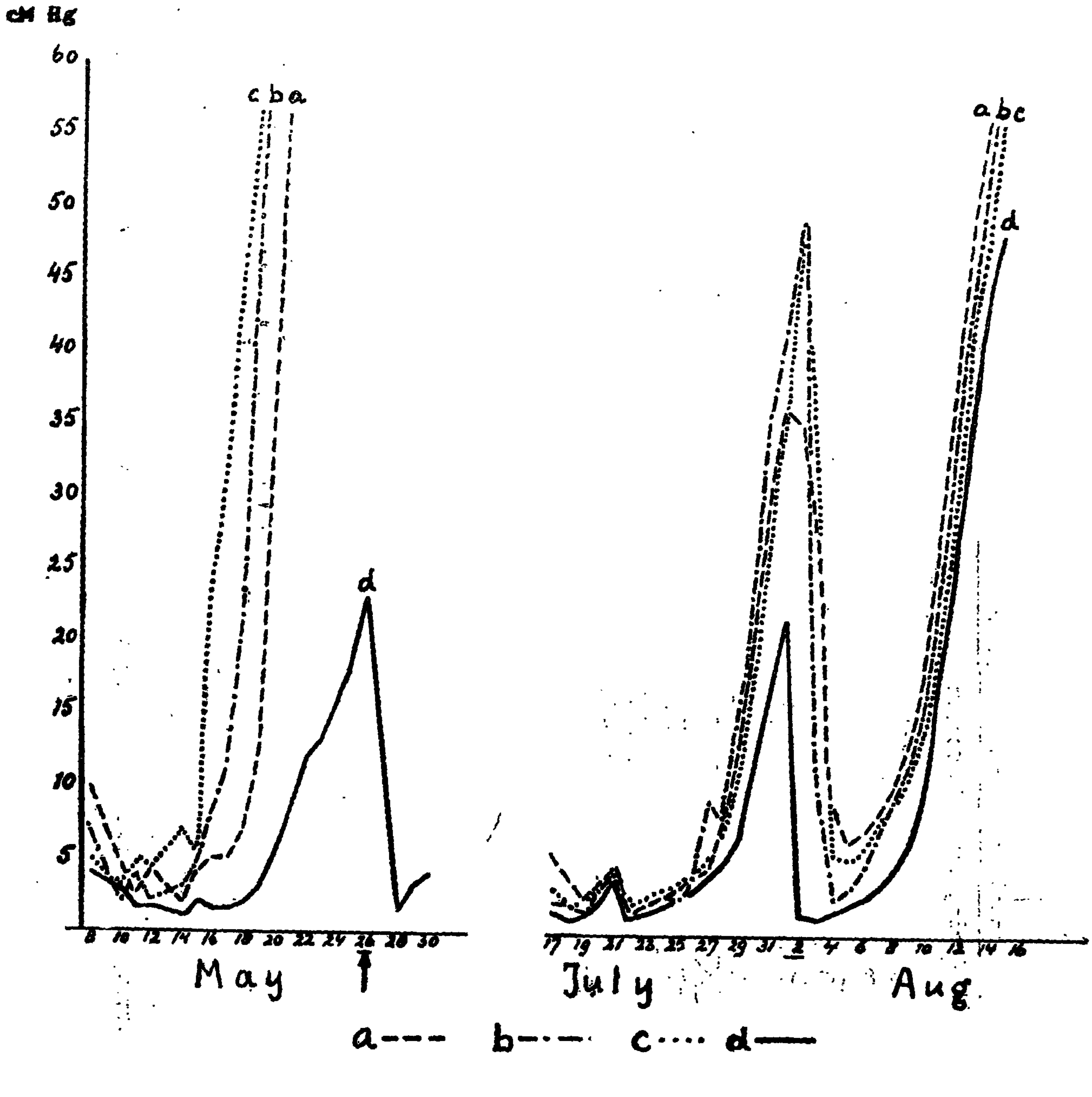


Fig. 3 Rainfall distribution and main operations during the 1962 season

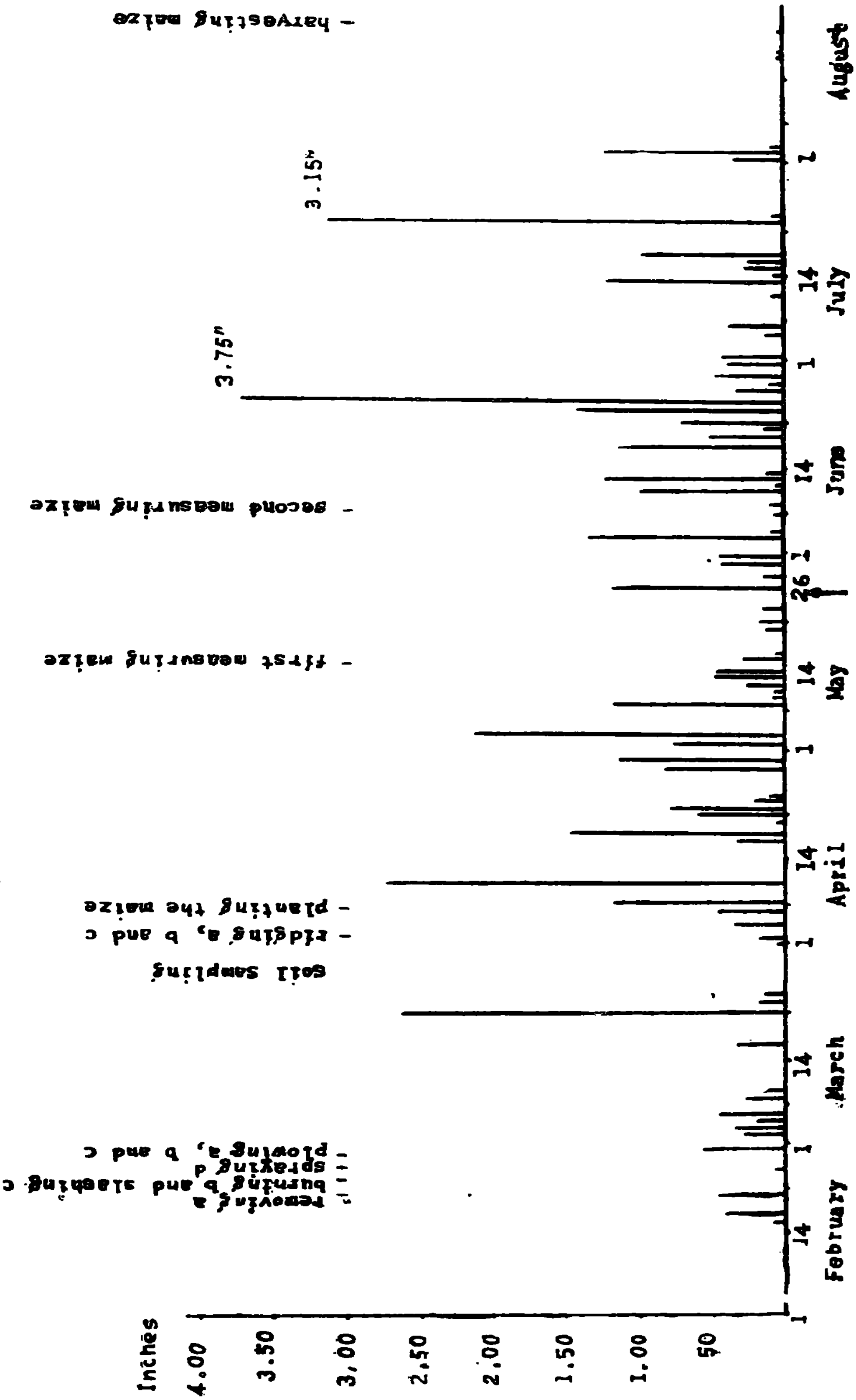


Fig.4A Treatment means for plantheights (1962)

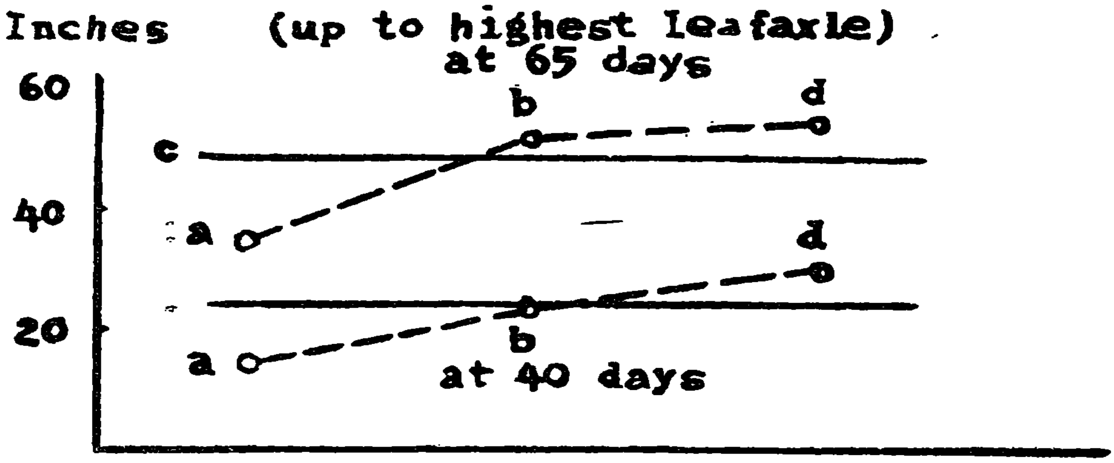


Fig.4B Treatment means for grainyields (14% moisture) per 100 undamaged stands (1962)

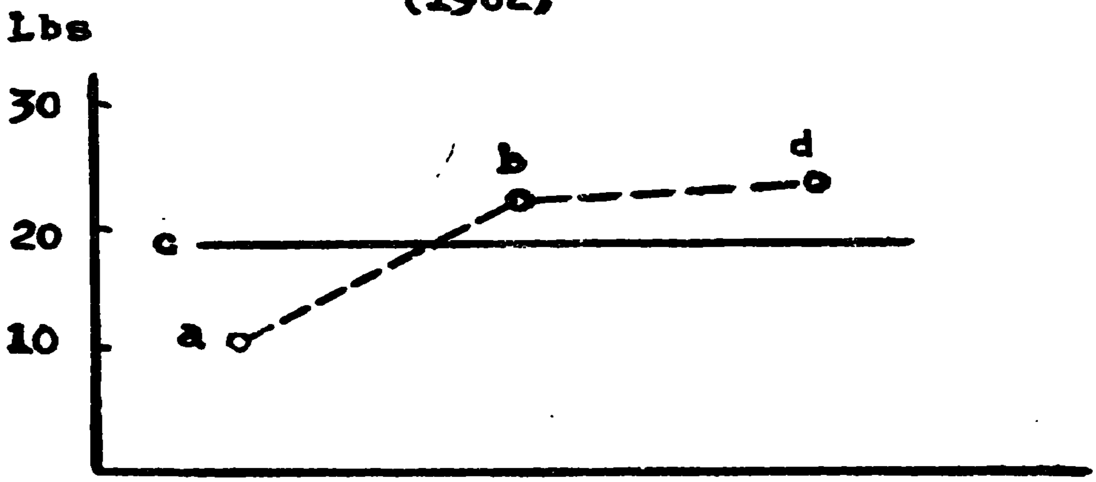


TABLE 1—Analysis of the Pueraria-cover

Blocks	*N*	*P*	*K*	*Ca*
	(*in % of the Dry Matter*)			
A	1·74	0·071	0·80	1·9
B	2·02	0·068	0·68	1·6
C	1·89	0·108	1·00	1·3
D	2·12	0·115	0·60	1·7
E	1·75	0·067	0·67	1·1
F	1·78	0·063	0·88	1·0
mean	*1·88*	*0·082*	*0·77*	*1·4*
Suriname	2·68	0·13	1·18	1·23
Lbs./acre	*117*	*5*	*48*	*87*
Yangambi :	301	15	108	82

TABLE 2—Analysis of the soil

Treatments	*pH* (H_2O)	*O. M.* %	*N* %	*P* *totl.* *ppm*	*C.E.C.* $NH_4=7$	*Ca*	*Mg*	*Mn*	*K*	*Na*	*T.E.B.*	*C.S.* %
					Extractable cations in m.e./100g							
a ..	4·81	2·03	·101	155	6·66	2·01	·69	·07	·09	·05	2·94	45
b ..	4·99	2·10	·105	162	7·00	2·27	·72	·06	·14	·07	3·14	46
c ..	4·97	2·26	·109	158	7·16	2·50	·68	·07	·13	·06	3·30	46
d ..	5·12	1·97	·101	149	7·04	2·34	·63	·06	·13	·07	3·14	46

O.M. = Organic Matter.
C.E.C. = Cation Exchange Cap.
T.E.B. = Total Exchangeable Basis.

Cation Saturation $= \frac{\text{T.E.B.}}{\text{C.E.C.}} \times 100\%$

TABLE 3.—Treatment effect on the growth of the maize (plantgrowth in inches)

Period	*Treatment means*				*Least Significant Difference for*	
	a	*b*	*c*	*d*	*P 0·05*	*P 0·01*
First 40 days	15·1	22·8	23·9	28·4	5·6	7·7
Next 25 days	35·9	50·3	48·1	52·3	6·7	9·2
Entire 65 days	51·0	73·1	72·0	80·7	10·1	14·0

Thus : during the first 40 days the maize of treatments b, c and d highly significantly outgrew that of treatment a, whereas the maize of treatment d further significantly outgrew that of treatment b, during the next 25 day period, as well as for the entire 65 days period, the maize of treatments b, c and d highly significantly outgrew that of treatment a only.

TABLE 4—Maize yields in lbs. of dry (14% moisture) grain per 100 harvested undamaged stands

Treatments	*a*	*b*	*c*	*d*	*Blockmean*
Blocks : A	23·3	36·8	27·2	37·2	31·1
B	12·3	31·4	26·3	37·3	26·8
C	8·3	15·3	22·2	26·2	18.0
D	3·5	13·4	9·5	18·0	11·1
E	8·0	16·2	18·4	16·2	14·7
F	4·9	19·2	8·5	6·4	9·7
Treatment means	10·1	22·1	18·7	23·6	
Lbs./acre	730	1,600	1,360	1,710	

L.S.D. for treatment means : for P = 0·05 is 5·7
for P = 0·01 is 7·8

Thus the maize of treatments *b*, *c* and *d* highly significantly outyielded that of treatment *a* only.

RESEARCH NOTE

Mango Losses due to Diplodia Stem-end Rot

V. N. Pathak and D. N. Srivastava

The stem-end rot of ripe mango fruits incited by *Physalospora rhodina* (Berk and Curt.) Cook (Syn. *Diplodia natalensis* Pole Evans) has characteristic symptoms and is distinct from lateral localised lesions or stem-end infection of the fruit incited by other fungi. In the initial stage, a small area on the epicarp around the base of the pedicel turns light brown. In the next few hours the affected area enlarges to form a circular snuff brown to black patch with fringed margin which under humid atmosphere extends rapidly, turning the whole fruit completely black within 2 to 3 days. The pulp of the diseased fruit becomes brown and somewhat soft (Fig. 1). Such fruits lose their market value completely.

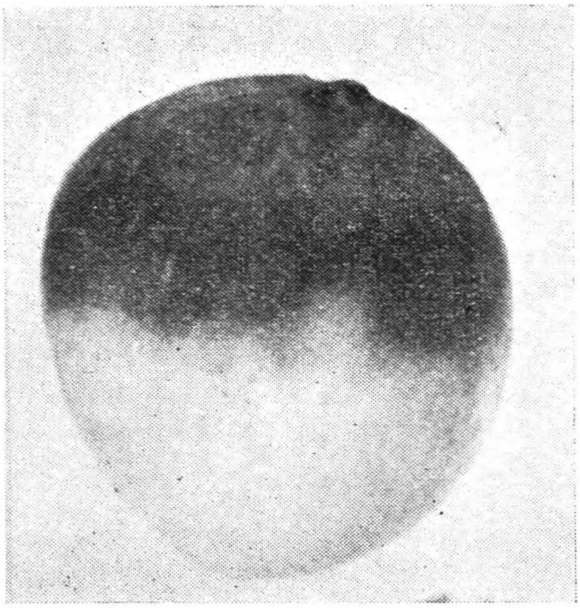


Fig. 1.—Mango fruit showing symptoms of *Diplodia* stem-end-rot

The disease is widespread and destructive. Wastage due to this disease from outside India (Su[3] and Fernando[2] is estimated between 2 to 10 percent. In India, Chakravarti and Srivastava [1] observed 10 per cent. infection of the *Langra* variety in Delhi markets.

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A study was undertaken to assess the extent to which fruits of different mango varieties commonly sold in Delhi market suffer from this disease. The fact that the disease manifests only in ripe fruits after release for sale in the retail market and that Delhi receives mangoes of many varieties from all parts of the country proved to be of advantage in this study. Subzimandi, the central market for fruits in the capital, was chosen for this purpose. In all, 5 visits were made at intervals of 30 days between the second week of April and end of August for three consecutive mango seasons of 1964, 1965 and 1966. Disease counts in the early varieties, viz., *Totapari, Sindoori, Piari* and *Himani* were made during April and May. In the case of *Langra, Dushehri, Sarauli* and *Chausa,* the counts were made in June, July and August and in the *Desi* only in August. The incidence of the disease was based on the number of mangoes infected out of 4 samples each of 125 fruits of each variety examined in four different shops selected at random during each visit. The average per cent infections for each year and for the three years are given in Table 1. Five infected fruits of each variety were picked up in every visit, brought to the laboratory and the association of the pathogen confirmed in all cases by isolation on PDA.

TABLE 1.—Incidence of Diplodia stem-end rot of mango fruits of different varieties in Delhi market

Variety of mango fruits	*Infection (per cent.)* 1964	1965	1966	*Average of the 3 years*
Totapari	5·0	3·1	5·0	4·3
Sindoori	4·7	3·9	3·8	4·4
Piari	4·5	3·3	4·6	4·1
Himani	4·7	3·6	4·7	4·3
Langra	6·4	4·3	8·0	6·2
Dushehri	6·2	4·0	6·9	5·7
Sarauli	5·6	3·7	7·9	5·7
Chausa	6·2	5·0	7·5	6·2
Desi	5·8	3·8	6·6	5·4

From the results in Table 1, it is seen that fruits of all the 9 varieties, including the *Desi,* showed varying degrees of stem-end rot. Maximum infection of 6.2 per cent for the three year period was recorded in *Langra* as against the minimum of 4.3 in *Totapari.* The per cent. infection in all the varieties was significantly higher in 1966 than in the other 2 years.

The incidence observed is within the range of 2 to 10 per cent. reported by earlier workers. The incidence of the disease is bound to vary with the class of the market. For example, one may not easily find a diseased fruit in any of the fruit stalls of Irwin Road where the shopkeepers meticulously exhibit the best fruits to attract the upper class moneyed customers. On the other hand, one may find mostly diseased fruits in the shops of the slum areas in Karol Bagh where the sub-retailers bring and sell diseased fruits discarded by the shopkeepers in superior markets. Since the disease manifests only in the ripened fruits, it is not possible to get a correct picture even from the average shopkeepers in Subzimandi, because the ripened fruits are on continuous sale and are replaced by newer consignments of less ripened ones. The only way to get a precise idea of the incidence of the disease is to purchase a large consignment of the varieties from the wholesalers and watch them for the incidence of the disease until they are over-ripe. This is undoubtedly an expensive proposition. Nevertheless, the results obtained clearly show that the disease is of considerable economic importance. Since only ripened fruits develop the disease, the actual parties affected are the retailers and the consumers. The orchard owner and wholesalers remain unaffected.

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