

# CHIPPING QUALITY AND YIELD OF 'NORCHIP' POTATOES DAMAGED BY SIMULATED HAIL

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## ABSTRACT

'Norchip' potato plants were subjected to simulated hail damage in a two-factor experimental design. The factors were degree of damage and time of damage in weeks post emergence. Hail was simulated by striking plants with lead spheres tethered to a hand-held rotating shaft. Losses due to simulated hail damage were assessed as quality loss, as measured by pre-harvest sugar concentration and post-harvest chip color, as yield loss, and as specific gravity loss. The experiment was replicated for four years. The results suggest that, in general, hail damage had little influence on chip color but could reduce yield to 64% of control by causing both reduced tuber weight and lower tuber number. Average specific gravity (an important quality attribute of chip potatoes) also fell from 1.096 to 1.085. **KEYWORDS.** Potatoes, Damage, Simulation, Chipping quality, Yield.

## INTRODUCTION

The economic return to producers of potatoes for chips is primarily affected by marketable yield rather than gross yield. To be marketable in the chipping industry, it is critical that potatoes have not only acceptable dry matter content (Orr and Graham, 1983) but also the ability to process into acceptably light-colored finished chips.

Previous research has shown that simulated hail damage reduces potato yield and that the reduction is related to intensity of the damage and to the stage of plant growth when the damage occurred (Takatori et al., 1952; Sparks and Woodbury, 1959; Murphy and Goven, 1962; Workman and Nye, 1982). These simulated-hail investigations studied yield losses in late maturing potato cultivars such as 'Russet

Burbank', 'Kennebec', and 'Katahdin' and were not concerned about tuber quality for processing into chips.

In the study reported here, we concentrated on determining the effects of simulated hail on tuber quality for processing into chips. Determination of effects upon yield was secondary. We assessed chip quality and yield effects in the early maturing 'Norchip' cultivar when subjected to simulated hail. 'Norchip' is currently the most important cultivar in the U.S. chipping industry.

## MATERIALS AND METHODS

'Norchip' potatoes were grown at the Potato Research Farm, Grand Forks County in the Red River Valley in the years 1981-1984. Cultural practices were common to the Red River Valley and included insect and disease control during the growing season. Each season, tubers were planted in May and harvested in September.

The basic experiment consisted of a 4x4 factorial arrangement of the two factors — intensity of simulated hail damage (0, 30, 45, and 80% defoliation) and time in weeks post emergence when the defoliation was performed (3, 5, 7, and 9 weeks). The time period was designed to begin subsequent to tuber initiation, include the entire period of rapid tuber growth and end prior to initiation of natural senescence. Emergence was defined as the date when 70% of the plants were visible. Each plot consisted of two 25 m rows spaced 0.9 m apart and separated from each other by an untreated guard row of 'Norchip' (cv).

We developed a hand-held device to simulate hail damage by striking stems and leaves with lead spheres. Lead spheres were tethered to a 60 cm line that was attached to a 2 m long by 5 cm diameter shaft. The shaft was rotated at 12.6 r / s by an electric drill. Thirteen tethered spheres were spaced 5 cm apart over the center 60 cm of the 2 m shaft. In operation, this device was held at right angles to the row at an appropriate height to damage the plant canopy and was moved the length of each row (fig. 1). Rate of forward progress along a row was modified to produce various degrees of injury to the plants. As the growing season progressed and plants became larger and more difficult to defoliate, the lead sphere sizes were increased, in a single step, from 20 gm to 50 gm in order to effect the correct degree of injury. If necessary, more than one pass was made to obtain the required degree of injury. The degrees of injury were: none, slight = 30%, moderate = 45%, severe = 80%. For each treatment, the degree of injury was verified by comparing the stem and leaf weight of 14 injured plants to 14 matching undamaged plants.

Tubers for sugar analysis were obtained by hand digging: 1) just before hail treatment, 2) at weekly intervals

Article has been reviewed and approved for publication by the Food and Process Engineering Inst. of ASAE in August 1991.

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Figure 1—Hail injury was simulated by striking plants with lead spheres tethered to a hand-held rotating shaft.

for 4 weeks following hail treatment, and 3) at the time of harvest. Tuber sucrose and glucose concentrations were measured by an industrial analyzer (Model #27, Yellow Springs Instrument Co., Yellow Springs, OH) using the method later described by Sowokinos et al. (1985). Sucrose concentration was also checked by the low-temperature anthrone procedure (Sowokinos, 1978).

Yield was determined by harvesting the remaining length of row. Remaining tubers were harvested with a single-row, mechanical plot harvester (Hassia). Specific gravity and tuber size were recorded. Specific gravity was determined by the hydrometer method (Gould and Plimpton, 1985). Tubers were stored 11 days at 20° C and then transferred in crates (holding 25 kg) to storage at 9° C and 90% RH. At monthly intervals after harvest, 6-8 tubers were sampled at random to determine long-term chipping quality. Each tuber was cut lengthwise and one half was sliced in a rotary chip slicer (Model 708-15, E. R. Knott Machine Co., Sharon, MA) into 0.13-cm thick slices. Slices were immediately rinsed in flowing tap water, drained, separated and conveyed on an agitating chain conveyor into the fryer (Heat and Control, Inc., San Francisco, CA). Chips were fried 90 s at 188° C in a corn and soybean oil blend, drained on a chain conveyor, bagged, and labeled. Chips were crushed into 1-2 cm pieces by hand manipulation of the bags and placed in the sample cup of a light-reflectance spectrophotometer (Agron, Model #M-300A/M-500A, Magnuson Engr., Inc., San Jose, CA) calibrated at zero and 97 (00 and 97 calibration disks) using the red mode.

TABLE 1. Average weekly sucrose and glucose concentrations by time and degree of damage for 1981-1984

| Degree of<br>Damage (R) | Time of<br>Damage (T) | Weeks Post Emergence |    |    |    |    |    |    |    |    |    |    |  |
|-------------------------|-----------------------|----------------------|----|----|----|----|----|----|----|----|----|----|--|
|                         |                       | 4                    | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13 | 14 |  |
| Sucrose (%) × 100       |                       |                      |    |    |    |    |    |    |    |    |    |    |  |
| Control                 |                       | 37                   | 39 | 49 | 43 | 29 | 26 | 16 | 11 | 16 | 13 | 14 |  |
| 30%                     | 3                     | .                    | 39 | 58 | 54 | .  | .  | .  | .  | 16 | 14 | 12 |  |
|                         | 5                     | .                    | 29 | 26 | 40 | 34 | 36 | .  | .  | 18 | 11 | 14 |  |
|                         | 7                     | .                    | .  | .  | 34 | 13 | 22 | 17 | 12 | 16 | 08 | 14 |  |
|                         | 9                     | .                    | .  | .  | .  | .  | 21 | 09 | 09 | 15 | 18 | 12 |  |
| 45%                     | 3                     | .                    | 32 | 50 | 52 | .  | .  | .  | .  | 17 | 19 | 14 |  |
|                         | 5                     | .                    | 35 | 15 | 29 | 37 | 45 | .  | .  | 17 | 12 | 13 |  |
|                         | 7                     | .                    | .  | .  | 39 | 10 | 16 | 16 | 12 | 16 | 13 | 15 |  |
|                         | 9                     | .                    | .  | .  | .  | .  | 20 | 08 | 10 | 14 | 20 | 16 |  |
| 80%                     | 3                     | .                    | 40 | 54 | 56 | .  | .  | .  | .  | 17 | 18 | 15 |  |
|                         | 5                     | .                    | 32 | 10 | 10 | 25 | 38 | .  | .  | 20 | 15 | 26 |  |
|                         | 7                     | .                    | .  | .  | 31 | 10 | 08 | 08 | 12 | 15 | 12 | 19 |  |
|                         | 9                     | .                    | .  | .  | .  | .  | 25 | 09 | 09 | 12 | 12 | 12 |  |
| Glucose (%) × 100       |                       |                      |    |    |    |    |    |    |    |    |    |    |  |
| Control                 |                       | 38                   | 28 | 19 | 11 | 08 | 05 | 04 | 03 | 02 | 02 | 01 |  |
| 30%                     | 3                     | 21                   | 25 | 25 | 22 | .  | .  | .  | .  | 02 | 02 | 01 |  |
|                         | 5                     | .                    | 21 | 18 | 11 | 07 | 05 | .  | .  | 02 | 02 | 01 |  |
|                         | 7                     | .                    | .  | .  | 10 | 06 | 05 | 03 | 02 | 02 | 01 | 01 |  |
|                         | 9                     | .                    | .  | .  | .  | .  | 06 | 02 | 02 | 02 | 01 | 01 |  |
| 45%                     | 3                     | 12                   | 21 | 34 | 30 | .  | .  | .  | .  | 02 | 04 | 01 |  |
|                         | 5                     | .                    | 23 | 13 | 10 | 07 | 05 | .  | .  | 02 | 02 | 01 |  |
|                         | 7                     | .                    | .  | .  | 11 | 04 | 04 | 04 | 03 | 02 | 02 | 01 |  |
|                         | 9                     | .                    | .  | .  | .  | .  | 05 | 03 | 02 | 02 | 03 | 04 |  |
| 80%                     | 3                     | .                    | 29 | 31 | 38 | .  | .  | .  | .  | 02 | 04 | 01 |  |
|                         | 5                     | .                    | 23 | 16 | 13 | 14 | 11 | .  | .  | 02 | 04 | 08 |  |
|                         | 7                     | .                    | .  | .  | 09 | 06 | 05 | 05 | 05 | 02 | 03 | 02 |  |
|                         | 9                     | .                    | .  | .  | .  | .  | .  | .  | .  | .  | .  | .  |  |



## RESULTS

Sucrose and glucose concentrations in tubers from control and hail damaged plants in week 4 through week 14 post emergence are presented in Table 1. Data points are average values for the years 1981-1984 for the different times of defoliation ( $T = 3, 5, 7$ , and  $9$  weeks post emergence) and degrees of defoliation ( $R = 0, 30, 45$ , and  $80\%$ ). Figure 2 contains weekly sucrose and glucose concentrations, transformed to log scale, for control and hail-damaged plants. Sucrose concentration in control tubers rose slightly until week 6, declined linearly through week 10 (linear regression estimate of slope [standard error] =  $-0.12 [0.015]$ ;  $R^2 = 96\%$ ) and then appeared to plateau. Glucose concentration in tubers from control plants declined linearly from week 4 through week 14 (linear regression estimate of slope [standard error] =  $-0.15 [0.009]$ ;  $R^2 = 97\%$ ). Sugar concentrations in tubers from hail-damaged plants, on average, converged to those of control plants after the early weeks.

Short term sucrose and glucose concentrations expressed as percentage of control for the first four weeks post hail damage are shown in figures 3 and 4 for the different levels of  $T$  and  $R$ . Relative sucrose fell from week 0 to week 1 and increased from weeks 1 through 4 in all treatment groups. The rates of increase appear similar for the different  $T$  within  $R$  (linear regression analysis did

not reveal any statistically significant differences). The relative sucrose concentration in tubers from plants receiving the highest amount of defoliation was consistently lower than that for tubers from plants with lower amounts of damage.

Relative glucose concentration increased from week 2 until week 4 in all early damaged plants ( $T = 3$ ) or in plants with intermediate time of damage ( $T = 5$  or  $T = 7$ ) that were damaged to the highest degree ( $R = 80\%$ ). Relative glucose concentration in late damaged plants ( $T = 9$ ) did not have any statistically significant time trend for any degree of damage. Glucose concentration trends, measured by linear regression coefficients, increased with increasing  $R$  and with decreasing  $T$ . The differences in slope were statistically significant ( $p < 0.01$ ).

Post harvest chip color, measured as Agtron means, for hail damaged plots averaged over 1981-1984 are presented in a two way "degree of damage" by "time of damage" format from harvest to eight months post harvest (Table 2). Agtron scores declined approximately 10 points one month after harvest and remained virtually constant, therefore, scores are presented only for months 0, 1, 4, and 8. Agtron values within each month post harvest differ very little except for the group exposed to the highest degree of damage in week 7 post emergence ( $T = 7$ ;  $R = 80\%$ ), which are consistently lowest.

Post harvest Agtron means for control plots (1), all damaged plots (2), and ( $T = 7$ ;  $R = 80\%$ ) (3) are presented by months post harvest (Table 3). Agtron scores declined considerably one month post harvest but remained constant for the next seven months. Monthly differences between control and hail damaged plots were very small but consistently positive so that their average is statistically significant (t-test;  $p < 0.01$ ). Monthly differences between the control and the ( $T = 7$ ;  $R = 80\%$ ) plots ranged from three to seven points and their average was statistically significant (t-test;  $p < 0.01$ ).

Yield components and specific gravity are presented in Table 4. These entries are average values for years 1981-1984. Average yield and average tuber weight declined sharply relative to control (37 and 28%, respectively, for  $R = 80\%$ ) as defoliation increased. The decrease was greatest when defoliation occurred in week 5 or 7. Linear regression analysis indicated that the rates of decline for week 5 or 7 are approximately twice those for week 3 or 9 and the difference is statistically significant (F-test;  $p < 0.05$ ). Tuber number also declined as damage increased (14% for  $R = 80\%$ ) and the rate of decline was statistically significant (F-test;  $p < 0.05$ ). As with yield and tuber weight, the decline was greater for week 5 or 7 than for week 3 and 9, but linear regression analysis indicated these differences were small and not statistically significant.

Average yield at the highest rate of damage was 64% of control (13,898 / 21,856) and the yield components, tuber weight and number of tubers, were 73 and 86% of their respective control values. The predicted yield (PY) due to the reduction in the yield components,

$$PY = 0.73 \times 0.86 = 0.63,$$

was in reasonable agreement with the observed results assuming the relationship:

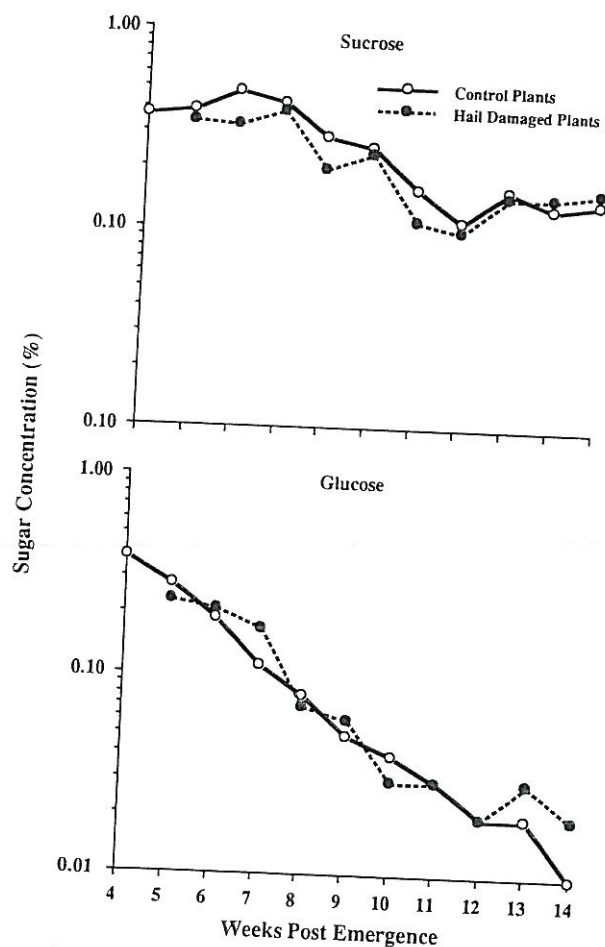


Figure 2—Seasonal sucrose and glucose concentrations (measured weekly) in tubers after simulated hail injury at different times after plant emergence.



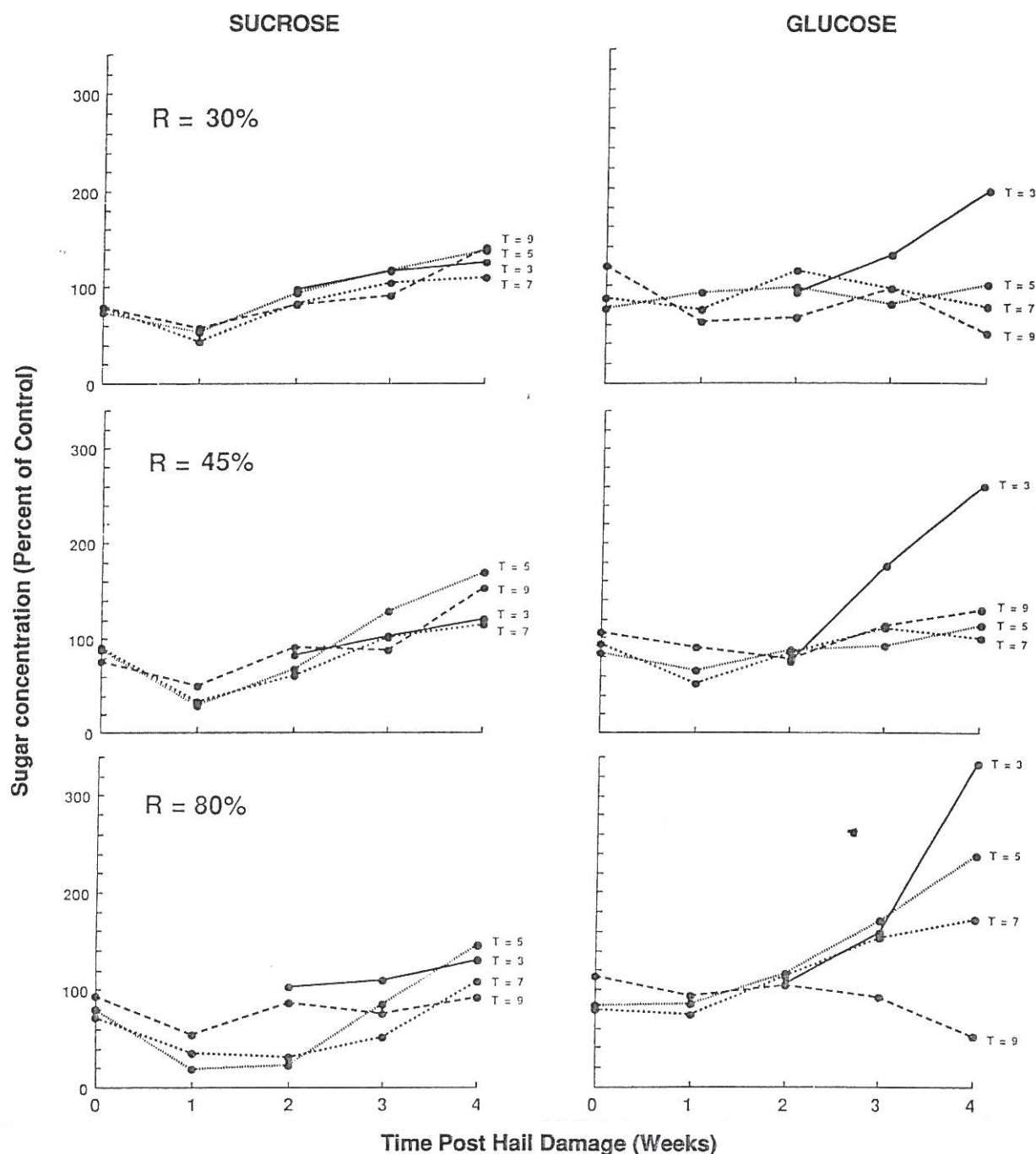


Figure 3—Short-term sucrose and glucose concentrations in tubers after different amounts of simulated hail injury (R) at different times after plant emergence.

yield / area = (weight / tuber)  $\times$  (number of tubers / area).

Specific gravity was unaffected by any "degree of damage" that occurred in week 3 and only exhibited a slight downward trend with increasing "degree of damage" when damage occurred in week 5. For week 7 and 9, specific gravity declined consistently as damage increased. The slopes as estimated by linear regression coefficients for weeks 5, 7, and 9 were statistically significant (F-test;  $p < 0.05$ ).

## DISCUSSION

For marketing acceptability in the chip industry, it is critical that potato tubers have the inherent qualities that result in acceptably light-colored chips when processed. Stresses to the growing plant could temporarily, or permanently, upset the ability of a chipping cultivar, such as 'Norchip', to produce light-colored chips. We determined the effects of simulated hail on chipping quality of 'Norchip' by measuring changes in the concentrations of sugars important to processing quality (sucrose and glucose) and the color of finished chips.



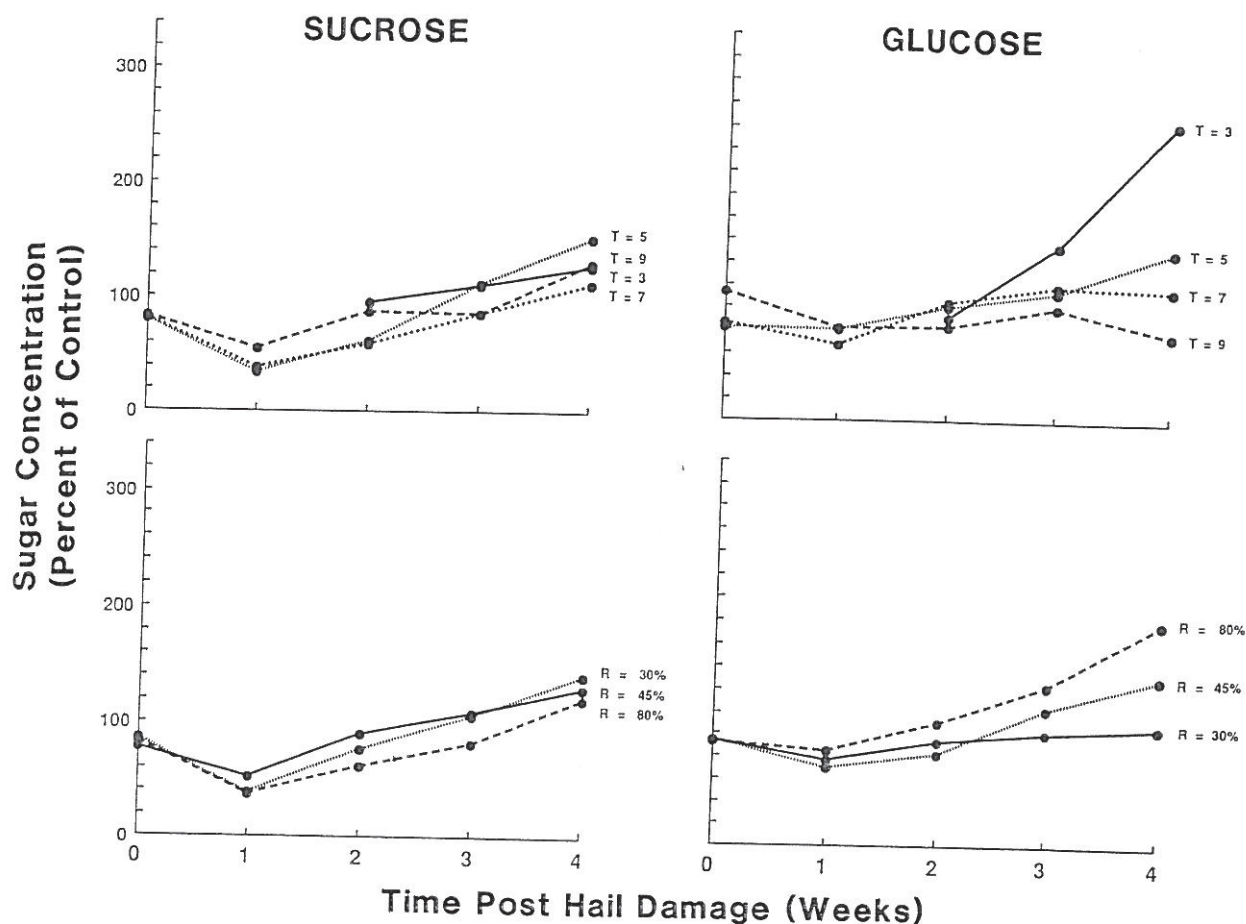


Figure 4—Short-term sucrose and glucose concentration in tubers after simulated hail injury (R) at different times (T) after plant emergence (combined by R and T).

TABLE 2. Post harvest Agtron means (1981-1984) by time and degree of damage

| Months<br>Post<br>Harvest | Time of<br>Hail<br>Damage (T) | Degree of Hail Damage (R) |     |     |      |
|---------------------------|-------------------------------|---------------------------|-----|-----|------|
|                           |                               | 30%                       | 45% | 80% | Mean |
| (Agron Value)             |                               |                           |     |     |      |
| 0                         | 3                             | 51                        | 51  | 53  | 52   |
|                           | 5                             | 50                        | 51  | 49  | 50   |
|                           | 7                             | 51                        | 50  | 47  | 50   |
|                           | 9                             | 51                        | 51  | 51  | 51   |
|                           | Mean                          | 51                        | 51  | 50  | 51   |
| 1                         | 3                             | 39                        | 38  | 39  | 39   |
|                           | 5                             | 39                        | 39  | 35  | 38   |
|                           | 7                             | 40                        | 38  | 34  | 37   |
|                           | 9                             | 39                        | 39  | 40  | 39   |
|                           | Mean                          | 39                        | 39  | 37  | 38   |
| 4                         | 3                             | 40                        | 41  | 40  | 40   |
|                           | 5                             | 41                        | 41  | 36  | 40   |
|                           | 7                             | 41                        | 39  | 34  | 38   |
|                           | 9                             | 40                        | 40  | 39  | 39   |
|                           | Mean                          | 41                        | 40  | 37  | 39   |
| 8                         | 3                             | 40                        | 40  | 41  | 40   |
|                           | 5                             | 38                        | 40  | 39  | 39   |
|                           | 7                             | 41                        | 41  | 36  | 38   |
|                           | 9                             | 40                        | 40  | 38  | 38   |
|                           | Mean                          | 40                        | 40  | 38  | 39   |

Changes in glucose or sucrose concentration due to simulated hail damage appear to be real, of small magnitude and transitory. Sucrose and glucose concentrations in all of the treated groups converged to control levels by week 12 or earlier. Sucrose was reduced for a short period before harvest but by harvest time sugar concentrations did not reflect any important hail damage trends.

TABLE 3. Post harvest Agtron means (1981-1984) for control plots (1), all damaged plots (2), and for plots exposed at week 7 post emergence (3) to the highest degree of defoliation

| Months<br>Post<br>Harvest | Control<br>Plots<br>(1) | Hail-Plots |                  | Difference |         |
|---------------------------|-------------------------|------------|------------------|------------|---------|
|                           |                         | All        | R = 80%<br>T = 7 | (1)-(2)    | (1)-(3) |
|                           |                         | (2)        | (3)              |            |         |
| (Agtron Value)            |                         |            |                  |            |         |
| 0                         | 51                      | 51         | 47               | 0          | 4       |
| 1                         | 40                      | 38         | 34               | 2          | 6       |
| 2                         | 40                      | 39         | 35               | 1          | 5       |
| 3                         | 38                      | 37         | 33               | 1          | 5       |
| 4                         | 41                      | 39         | 34               | 2          | 7       |
| 5                         | 41                      | 40         | 34               | 1          | 7       |
| 6                         | 40                      | 39         | 35               | 1          | 5       |
| 7                         | 41                      | 40         | 36               | 1          | 5       |
| 8                         | 40                      | 39         | 37               | 1          | 3       |
| Mean                      | 41.3                    | 40.7       | 36.1             | 1.1        | 5.2     |
| Stand. Error              | 1.2                     | 1.4        | 1.4              | 0.20       | 0.43    |



TABLE 4. Yield, yield components, and specific gravity means for 1981-1984 by time and degree of damage

| Variable         | Time of Damage | Degree of Damage (R) |        |        |        |         |
|------------------|----------------|----------------------|--------|--------|--------|---------|
|                  | (T)            | 0                    | 30%    | 45%    | 80%    | Average |
| (kg / ha)        |                |                      |        |        |        |         |
| Yield/Area       | 3              | 21,968               | 20,063 | 19,727 | 16,364 | 19,502  |
|                  | 5              | 21,632               | 19,278 | 16,924 | 11,993 | 17,485  |
|                  | 7              | 22,192               | 18,942 | 16,028 | 11,769 | 17,149  |
|                  | 9              | 21,856               | 20,175 | 17,373 | 15,355 | 18,718  |
|                  | Mean           | 21,856               | 19,614 | 17,485 | 13,898 | 18,157  |
| (gram)           |                |                      |        |        |        |         |
| Tuber            | 3              | 372                  | 355    | 334    | 304    | 341     |
|                  | 5              | 365                  | 334    | 303    | 229    | 308     |
|                  | 7              | 359                  | 343    | 303    | 238    | 310     |
|                  | 9              | 376                  | 355    | 336    | 298    | 341     |
|                  | Mean           | 368                  | 347    | 319    | 267    | 325     |
| (No. / ha)       |                |                      |        |        |        |         |
| Tubers / Area    | 3              | 1327                 | 1255   | 1312   | 1206   | 1275    |
|                  | 5              | 1344                 | 1305   | 1233   | 1139   | 1255    |
|                  | 7              | 1376                 | 1231   | 1176   | 1090   | 1216    |
|                  | 9              | 1307                 | 1297   | 1176   | 1156   | 1233    |
|                  | Mean           | 1339                 | 1273   | 1226   | 1147   | 1245    |
| Specific Gravity | 3              | 1.097                | 1.097  | 1.097  | 1.096  | 1.097   |
|                  | 5              | 1.096                | 1.096  | 1.095  | 1.088  | 1.094   |
|                  | 7              | 1.095                | 1.091  | 1.091  | 1.074  | 1.088   |
|                  | 9              | 1.096                | 1.093  | 1.089  | 1.083  | 1.090   |
|                  | Mean           | 1.096                | 1.094  | 1.093  | 1.085  | 1.092   |

Hail damage may reduce Agtron values by four to nine points if massive hail defoliation occurs in or near week 7 post emergence. In general though, hail should not be an important factor in tuber quality with respect to post harvest chip color.

Yield components and specific gravity declined as damage increased and were most sensitive to hail damage which occurred in week 5 or 7 post emergence. Both components of yield were reduced by hail damage but tuber weight was reduced more than tuber number.

Insofar as simulated hail damage reflects real hail damage, these results indicated that hail lowered 'Norchip' yield and specific gravity but did not meaningfully reduce chip color as measured by Agtron, sucrose, or glucose values.

## REFERENCES

- Gould, W.A. and S. Plimpton. 1985. Quality evaluation of potato cultivars for processing. NCR Res. Pub. No. 305. Ohio State University, Columbus.
- Murphy, J.J. and M.J. Goven. 1962. The effect of simulated hail damage on yield and quality of potatoes in Maine. Bul. No. 607. Maine Agr. Exp. Sta., Orono.
- Orr, P.H. and C.K. Graham. 1983. Determining least-cost sources of chipping potato by use of mathematical models. *Transactions of the ASAE* 25(1):297-300, 304.
- Sowokinos, J.R., E.C. Lulai and J.A. Knoper. 1985. Translucent tissue defects in *Solanum tuberosum* L. I. Alterations in amyloplast membrane integrity, enzyme activities, sugars and starch content. *Plant Physiol.* 78:489-494.
- Sowokinos, J.R. 1978. Relationship of harvest sucrose content to processing maturity and storage life of potatoes. *Amer. Potato J.* 55:333-344.
- Sparks, W.C. and G.W. Woodbury. 1959. Stages of potato plant growth — A guide in estimating losses from defoliation. Bul. No. 309. Idaho Agr. Exp. Sta., Aberdeen.
- Takatori, F.H., W.C. Sparks and G.W. Woodbury. 1952. A study of simulated hail injury on potatoes. Bul. No. 22. Idaho Agr. Exp. Sta., Aberdeen.
- Workman, M. and P. Nye. 1982. A comparison of Russet Burbank and Centennial cultivars in response to simulated hail injury and in vine and tuber growth. Bul. No. 1010. Colorado Agr. Exp. Sta., Ft. Collins.



ESTUDIOS DEL NIVEL ECONOMICO DE DAÑO DE LA POLILLA DE LA PAPA,  
*Phthorimaea operculella* (Zeller) (Lepidoptera: Gelechiidae)

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RESUMEN

En el Centro Regional de Investigación "La Selva" del Instituto Colombiano Agropecuario (ICA), en el Municipio de Rionegro (Antioquia) y durante dos semestres, 1986B y 1987A, se estudiaron los factores que permitieron establecer los parámetros relacionados con el nivel económico de daño de la polilla de la papa *Phthorimaea operculella* (Zeller).

El daño del área foliar por larva en el campo fue de  $6.29 \pm 1.32 \text{ cm}^2$ , porcentajes de defoliación simulada de 0, 25, 50 y 75% por una sola vez y cuando las plantas tenían 35, 55 y 75 días de edad, indicaron que defoliaciones superiores al 25% afectaron los rendimientos y calidad de los tubérculos.

Los análisis de regresión para medir la relación entre el daño foliar y su efecto en la producción para la época de estos estudios, para cada edad del cultivo estudiada y asumiendo una o tres aplicaciones de insecticidas, mostraron los siguientes niveles de daño económico:

Para el cultivo de 35 días, con una o tres aplicaciones de insecticidas, los niveles de daño fueron 3.19 y 9.6 larvas/planta, respectivamente. A los 55 días de edad del cultivo, con una o tres aplicaciones, los niveles de daño fue-

ron 2.44 y 7.35 larvas/planta, respectivamente y en el cultivo de 75 días de edad, con una y tres aplicaciones de insecticidas, los niveles de daño fueron 4.48 y 6.65 larvas/planta, respectivamente.

SUMMARY

A study was carried out at "La Selva" Experiment Station, located at Rionegro (Antioquia, Colombia), during the second semester of 1986 and the first of 1987. The objective was to determine the parameters related with the economic level of damage caused by *Phthorimaea operculella* (Zeller).

The leaf area damaged by the insect at the field was  $6.29 \pm 1.32 \text{ cm}^2$  simulated percentages of 0, 25, 50 and 75% of defoliation at once and when the plant was 35, 55 and 75 days old, indicated that, the levels above 25% affected the yield and the tuber quality.

A regression analysis to measure the relationship between foliar damage and yield for each one of the crop ages studied and one to three insecticide applications showed the following results: For the 35 days old crop with one and three insecticide applications, the damage levels were 3.19 and 9.6 worms by plant. For the 55 days old crop with one and three insecticide applications the damage levels were 2.44 and 7.35 worms by plant. An for the 75 days old crop the damage levels were 4.48 and 6.65 worms by plants, respectively.

INTRODUCCION

*Phthorimaea operculella* (Zeller) es un insecto que ataca el follaje de las plantas de papa y sus tubérculos, tanto en el campo como en el almacenamiento. En Colombia, en los últimos años, se han registrado frecuentes ataques en los departamentos de Boyacá, Cundinamarca y más recientemente en Antioquia.

En Colombia, poco se conoce en relación con el nivel económico de daño de *P. operculella*. Este desconocimiento obliga a los agricultores al uso indiscriminado de insecticidas que, muchas veces, ha resultado contraproducente económica y ecológicamente.

El objetivo principal del presente estudio fue cuantificar el efecto de defoliaciones simuladas en la producción del cultivo de la papa y relacionarlo con el daño causado por la polilla de la papa, para establecer un nivel económico de daño.

REVISION DE LITERATURA

Al *P. operculella* se lo conoce con los nombres comunes de: "gorgojo de la papa" (H. Berton en 1954), "el gusano del tubérculo de la papa" (Zeller, según su descripción hecha en 1873) y, en Colombia, como "palomilla del tubérculo de la papa" (Benavides, 1981; CIP, 1980; López et al., 1981; Piedrahita et al., 1983; Posada et al., 1986; Valencia, 1985).

Según Povolny (16), las sinonimias del insecto son: *Phthorimaea terrella* Walker 1873. El nombre *terrella* no fue

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