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Curling Burley Tobacco from an Automated Harvesting System

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Curing Burley Tobacco from an Automated Harvesting System

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Abstract

If burley tobacco can be successfully cured at high density under waterproof covers in the field, a producer can expand production without the necessity of building new curing barns and can thereby more easily justify investment in the automated burley tobacco harvesting system (Wells et al., 1990a, b). Curing under waterproof covers in the field and curing on frames in the barn were evaluated over three curing seasons using two varieties (KY 14 and TN 86), two plant densities (32 and 43 plants/m^2, 3 and 4 plants/ft^2), position of tobacco on the frame (four levels ranging from edge to center) and stalk position (bottom, middle and top). Conventionally cured tobacco was used as the standard of comparison and grade index was used as the assessment of quality.

Averaged over a three-year period, burley tobacco cured in the field over sod and under waterproof covers and conventionally cured tobacco were of equal quality (56.0 and 55.8 grade index, respectively) and were both superior to tobacco cured on frames in the barn (52.0). During the dry curing season, burley tobacco cured under the covers had a higher grade index (54.9) than that cured conventionally (43.5) or on frames in the barn (43.7) but during the moderately wet and wet curing seasons, conventionally cured burley tobacco had a higher grade index (62.3 and 61.5, respectively) than that cured under covers (58.9 and 54.2, respectively) or on frame in the barn (59.0 and 53.4, respectively). During the wet curing season, leaf tips near the sod in the field and near the concrete in the barn cured dark red resulting in a lowered grade index. Burley tobacco from the automated harvesting system is better cured outside under waterproof covers than cured in a barn. **Keywords.** Automated harvesting system, Burley tobacco.

Introduction

Wells et al. (1990a, b) have developed a fully automated burley tobacco harvester. Plants are harvested at a rate of 1.4 ha/day (3.5 A/day) on a 2.4 by 4.3 m (8 by 14 ft) steel frame at a density of 43 plants/m^2 (4 plants/ft^2). Two curing alternatives exist for this system. One is traditional curing in a conventional barn but at a plant density about twice that of conventional curing. The second alternative is curing under waterproof covers in the field without the need for a curing barn. The economic incentive for the latter curing alternative is obvious. A producer would be able to expand production without building a new barn or renting barn space from a neighbor which may be well removed from the producer's field. In 1990 producers will be allowed to lease 6800 kg (15,000 lb) more than in previous years and will be allowed to buy quota for the first time.

Yoder and Henson (1974) showed the efficacy of curing under plastic but at a lower plant density (32 plants/m^2, 3 plants/ft^2). Their method of using polyethylene was not deemed to be feasible for the current system, therefore a multiple year curing experiment was conducted to evaluate curing at high density on steel frames both in the barn and in the field under waterproof covers. Specific objectives were to:

- Determine the effect of curing season, variety, curing treatment (barn or field curing), plant density, plant position on frame (edge vs. center) and stalk position on the quality of the cured leaf as assessed by grade index.
- Compare curing on portable frames in the field under covers and in the barn and under conventional curing methods.

Materials and Methods

A factorial experiment was designed to determine the effect of curing season (1987, 1988, and 1989), variety (KY 14 and TN 86), curing treatment (frames of tobacco curing in the field under waterproof covers and frames of tobacco cured in the barn), plant density (32 and 43 plants/m^2; 3 and 4 plants/ft^2), position of tobacco on the frame (4 levels ranging from the edge to the center) and stalk position (bottom, middle and top) on quality of burley tobacco. Grade index was used as the assessment of quality (Bowman et al., 1989). There were two replications.

Two varieties, KY 14 and TN 86, were harvested using the automatic harvesting system developed by Wells et al. (1990a, b). The metal frame of the automatic harvester is comprised of eight 4.3 m (14 ft) long rails spaced 0.3 m (1 ft) apart. A cross section of the rail containing a notched plant is shown in figure 1. The rails are held rigidly in place by a metal box frame. For the purpose of evaluating curing among rails, rail positions were designated as edge, second from edge, third from edge, and center rail. One side of each frame (four rails) was filled to a density of 32 plants/m^2 (3 plants/ft^2) while the other side was filled to a

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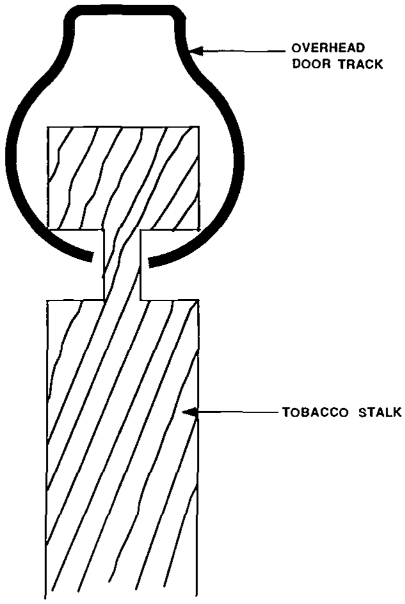

Figure 1–Cross-section of the rail containing a notched plant.

density of 43 plants/m^2 (4 plants/ft^2). Each frame was replicated twice.

Eight frames were filled with tobacco during a three hour period, during each of the three years. All frames were removed to a sod area for one week of field curing after which four frames were transported to the barn to finish field curing and four frames were covered in the field with a spun polypropylene cover with waterproof coating to finish curing.

Tobacco from both varieties was hand harvested and cured in a conventional curing barn. This tobacco was used as a standard of comparison.

Six plants were randomly selected from each rail. Eight sticks (6 plants/stick) were randomly selected from each variety of conventionally cured tobacco. Leaves were removed from the stalk and placed into three stalk positions (bottom, middle, and top). Representatives from the Agricultural Marketing Service inspected the tobacco and assigned a federal grade to each sample. Federal grade was converted to its corresponding grade index (Bowman et al., 1989) for analysis. The effect of treatments of the mechanically harvested tobacco on the quality of burley tobacco as assessed by grade index was determined by analysis of variance. Differences among means were determined by Duncan's new multiple range test. Tobacco cured on the frames was compared to conventionally cured tobacco and statistical analyses performed as appropriate.

Results and Discussion

The three years of this study comprised an excellent range of curing seasons. For 1987, days one through three of the cure averaged about 57% relative humidity and days eight through twelve averaged 54% compared to the desired 65 to 70% mean daily relative humidity (Walton et al., 1971). Since undesirable colors from overdrying are established over periods of a few days during the first and second week of curing (Walton et al., 1971), 1987 may be categorized as a dry season. Mean daily relative humidity was high during days one through twenty one (average = 76%) during 1988 but was lower during days twenty two through thirty five such that the average over 35 days of curing was 72%. Over all, the 1988 curing season may be categorized as a moderately wet season. For 1989, the mean daily relative humidity was consistently high throughout the cure with an average relative humidity of 76% over 35 days. The 1989 curing season may be categorized as a wet curing season.

Comparison of Mechanically Harvested Burley Tobacco Cured on Portable Frames in the Barn and in the Field

The analysis of variance showed the effect of curing season, curing treatment, and stalk position on grade index to be significant at the 1% level. Variety, density, and rail position had no effect on grade index. Significant interactions were curing season-variety (5% level), curing season-curing treatment (5%), curing season-rail position (5%), curing season-stalk position (1%), curing treatment-stalk position (5%), and curing season-variety-stalk position (1%).

Mean values of grade index as a function of curing season, variety, curing treatment, density, rail position, and stalk position are shown in Table 1. The 1987 curing season had a significantly lower mean grade index than the 1988 and 1989 curing seasons. The penalty for overdried tobacco is much greater than penalty for underdried tobacco which is a reflection of the usefulness of the respective tobaccos to the industry.

Tobacco cured on the frames entirely in the field over sod and under waterproof covers was superior to tobacco cured on the frames in the barn as shown by the means of Table 1. The superiority of curing in the field compared to curing in the barn was confined to the middle and top stalk positions (Table 2). The bottom stalk position showed no difference in grade index between curing treatments

TABLE 1. Mean values of grade index as a function of curing season, variety, curing treatment, plant density, rail position, and stalk position

Treatment	Grade Index
1987 curing season	48.4 a*
1989 curing season	57.9 b
1988 curing season	59.2 b
KY 14	55.8 a
TN 86	54.6 a
Field cured under covers	57.0 a
Barn cured on frames	53.4 b
32 plants/m^2 (3 plants/ft^2)	55.6 a
43 plants/m^2 (4 plants/ft^2)	54.8 a
Rail 1 - edge	55.3 a
Rail 2	55.2 a
Rail 3	55.5 a
Rail 4 - center	54.8 a
Middle stalk position	61.9 a
Top stalk position	55.3 b
Bottom stalk position	48.4 c

* Means, within a treatment, with different letters beside them are significantly different by Duncan's new multiple range test (5% level).

because its over-mature leaves responded less to differences in curing environments than did the mature leaves and under-mature leaves of the middle and top stalk positions, respectively. Means for the curing season-curing treatment shown in Table 2 indicate that the curing treatment trend from Table 1 was not consistent over curing season. Field cured tobacco had a much higher grade index (53.9) than did tobacco cured in the barn on frames (42.9) during the dry curing season of 1987. There was little difference in grade index between tobacco cured on frames in the field and in the barn during the 1988 and 1989 curing seasons.

Average temperature and relative humidity during a dry 4-day period early in the cure in 1987 under the waterproof cover and directly above the tobacco is compared to ambient temperature and relative humidity in figures 2 and 3, respectively. Relative humidity reached saturation under the cover during the night. Relative humidity was 18 to 25% higher under the cover than ambient during the night and 7 to 10% lower under the cover than ambient during the day. Temperature was 2° C (4° F) lower under the cover than ambient during the night and 7 to 12° C (13 to 22° F) higher under the cover than ambient during the day. Both mean temperature and relative humidity were higher under the cover than the ambient mean temperature and relative humidity. In 1987, the higher relative humidity under the cover cured better quality tobacco on frames in the field compared to tobacco cured on frames in the barn. The higher relative humidity under the cover did not cause lower quality tobacco during 1988 and 1989 because underdrying tobacco results in very little penalty by the industry.

TABLE 2. Mean values of grade index for the curing treatment-stalk position, curing season-curing treatment and curing season-rail position interactions

Curing Season or Stalk Position	Curing Treatment or Rail Position	Grade Index
Bottom s.p.	Field cured under covers	48.6
Bottom s.p.	Barn cured on frames	48.2
Middle s.p.	Field cured under covers	59.3
Middle s.p.	Barn cured on frames	59.3
Top s.p.	Field cured on frames	58.0
Top s.p.	Barn cured on frames	52.5
1987	Field cured under covers	53.9
1987	Barn cured on frames	42.9
1988	Field cured under covers	58.5
1988	Barn cured on frames	59.9
1989	Field cured under covers	58.6
1989	Barn cured on frames	57.3
1987	Edge rail	47.3
1987	Rail 2	46.6
1987	Rail 3	50.9
1987	Center rail	48.8
1988	Edge rail	59.2
1988	Rail 2	58.5
1988	Rail 3	60.0
1988	Center rail	59.0
1989	Edge rail	59.5
1989	Rail 2	60.3
1989	Rail 3	55.4
1989	Center rail	56.5

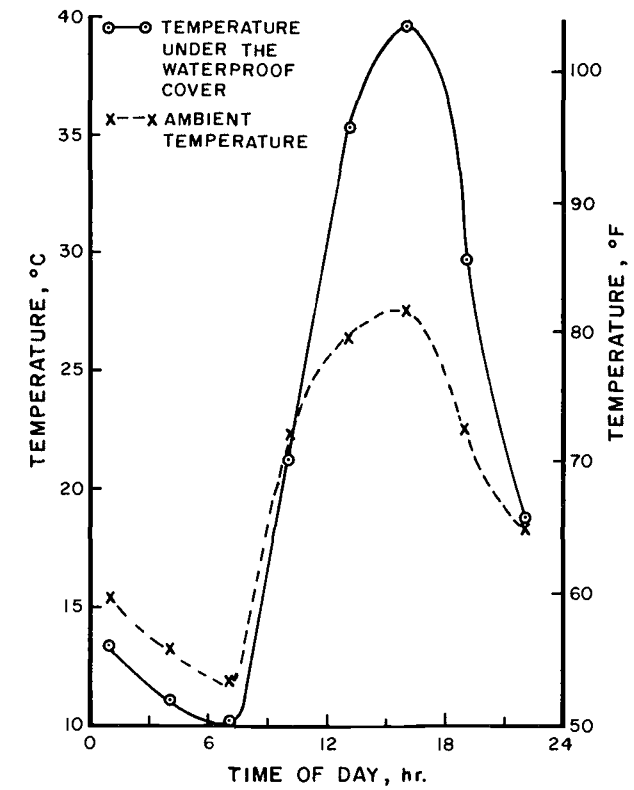

Figure 2–Temperature under the waterproof cover and directly above tobacco and ambient temperature, both averaged over four dry days in 1987.

The middle stalk position (Table 1) had a higher mean grade index than the top stalk position which in turn had a higher mean grade index than the bottom stalk position. The bottom stalk position was expected to have a lower grade index since its maximum value is 90 compared to 100 for the middle and top stalk position. The lower grade index for the top stalk position compared to the middle stalk position was primarily a result of leaf tips near the sod and near the concrete curing dark red during the wet curing season of 1989. This penalty was confined to the variety TN 86 because it had large plants that hung within 0 to 15 cm (0 to 6 in) of the ground while KY 14 had inexplicably small plants that hung at least 46 cm (18 in) above the ground. Leaves from the top stalk position of the TN 86 cured dark red in 1989 while the KY 14 did not which resulted in the significant interactions of curing season-variety and curing season-variety-stalk position. Therefore any variety effect was due not to variety but to the disparity in plant size between varieties observed only during 1989.

The curing season-rail position interaction (Table 2) showed that in the dry year of 1987, the two rails of tobacco closest to the center cured better than the two rails of tobacco closest to the edge. In 1988 there was little difference among the rails. In the wet year of 1989, the two rails of tobacco closest to the edge cured better than the two rails of tobacco closest to the center. The logical explanation for this curing pattern is airflow. It is reasonable to surmise an airflow pattern that is higher near the edge of the frame than the center for both covered frames in the field and frames in the barn. Such an airflow

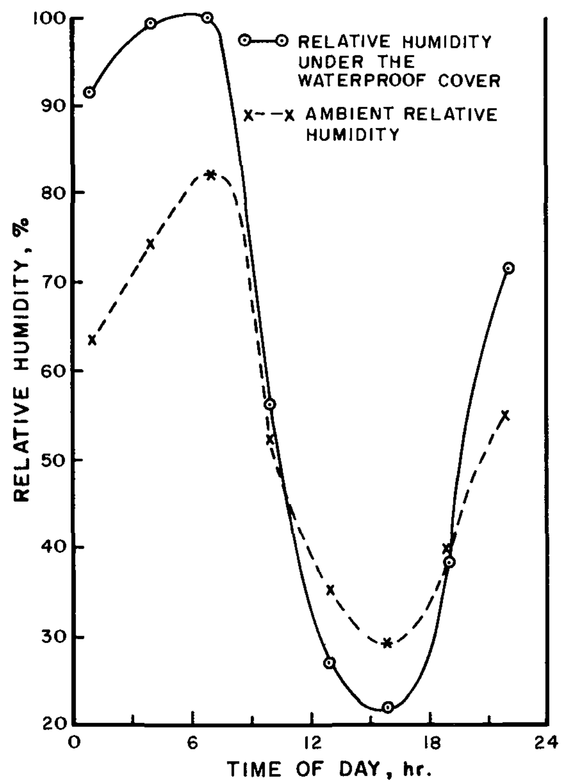

Figure 3–Relative humidity under the waterproof cover and directly above the tobacco and ambient relative humidity, both averaged over four dry days in 1987.

pattern would result in slower curing in the center of the frame than at the edge. The slower drying rate in the center was an advantage during the dry year and a disadvantage during the wet year which follows the curing pattern. The moderately wet year may not have departed enough from the norm to create a difference among rails.

Comparison of Mechanically and Conventionally Harvested Burley Tobacco Curing

To compare tobacco cured in the field under covers and tobacco cured on frames in the barn to conventionally cured tobacco, an analysis of variance was carried out using the conventional data as a curing treatment. Only the data from TN 86 and 43 plants/m^2 (4 plants/ft^2) density were used in this analysis. Rail position was treated as a replication making a total of eight replications. Mean values of grade index are shown in Table 3 as a function of curing season, curing treatment, and stalk position. Stalk position showed the same differences among means as before. Curing season, however, showed that 1988 curing season had a significantly higher grade index than the 1989 curing season which had a significantly higher grade index than the 1987 curing season.

Over the three-year period, tobacco cured in the field under covers and conventionally cured tobacco were of equal quality and were both superior to tobacco cured on frames in the barn. The potential economic benefits from curing burley tobacco in the field under waterproof covers are tremendous. Curing outside under waterproof covers is a system that offers the possibility of expansion of production with greatly reduced investment because the system is an inexpensive alternative to building new barns that cost about $12,500/ha ($5,000/acre) .

The analysis of variance using conventional curing as a curing treatment showed that the year-curing treatment interaction was significant at the 5% level. Each year was then analyzed separately so that Duncan's new multiple range test could be used to differentiate between means of curing treatments within each curing season. Mean values of curing treatment for each curing season are shown in Table 4. During the dry curing season of 1987, curing under the covers was superior to both conventional curing and barn curing on frames. Curing under the covers promises to greatly reduce the undesirable yellow and green hues that so greatly diminish the desirability of burley tobacco to industry (Sykes, 1990). During the moderately wet season of 1988 and the wet season of 1989 conventionally cured tobacco was superior to both tobacco cured under covers and tobacco cured in the barn on frames. Clearly, curing on frames in the barn was not as good as curing under covers or conventional curing over the three year period. Conventional curing has a density of 21.5 to 27 plants/m^2 (2 to 2.5 plants/ft^2). This lower density has been shown by Walton et al. (1990) to have an advantage in curing over higher densities which logically would be greatest during wet curing seasons. Curing under covers has an advantage in dry seasons because of the moisture holding capacity of the waterproof cover. Curing on frames in the barn would appear to have no attributes

TABLE 3. Mean values of grade index as a function of curing season, curing treatment (including conventional curing), and stalk position

Treatment	Grade Index
1988 curing season	60.0 a*
1989 curing season	56.4 b
1987 curing season	47.4 c
Field cured under covers	56.0 a
Conventionally cured	55.8 a
Barn cured on frames	52.0 b
Middle stalk position	62.8 a
Top stalk position	53.2 b
Bottom stalk position	47.8 c

* Means, within a treatment, with different letters beside them are significantly different by Duncan's new multiple range test (5%).

TABLE 4. Mean values of grade index as a function of curing treatment (including conventional curing) with each curing season being analyzed separately

Curing Treatment	Year	Grade Index
Field cured under covers	1987	54.9 a*
Barn cured on frames		43.7 b
Conventionally cured		43.5 b
Conventionally cured	1988	62.3 a
Barn cured on frames		59.0 b
Field cured under covers		58.9 b
Conventionally cured	1989	61.5 a
Field cured under covers		54.2 b
Barn cured on frame		53.4 b

* Mean values of curing treatment within a given year with different letters beside them are significantly different by Duncan's new multiple range test (5% level).

which would give it an advantage during either dry or wet seasons.

Conclusions

Our conclusions were:

1. Averaged over a three-year period from 1987 to 1989, tobacco cured in the field over sod and under waterproof covers and conventionally cured tobacco were of equal quality and were both superior to tobacco cured on frames in the barn.
2. Burley tobacco from the automated harvesting system is better cured outside under covers than in a barn.
3. The relative humidity under the covers reaches saturation during the night which is an advantage during dry curing seasons and a disadvantage during wet curing seasons.
4. During the dry curing season, burley tobacco cured under the covers had a higher grade index than that cured conventionally or on frames in the barn but during the moderately wet and wet curing seasons, conventionally cured tobacco had a higher grade index than that cured under covers or on frames in the barn.
5. Plant density on the frames (32 and 43 plants/m^2, 3 and 4 plants/ft^2) had no effect on grade index when left in the field for one week of field curing before covering or barning.
6. The curing pattern on the frames indicated more airflow near the edge of the frame than near the center.
7. During the wet curing season of 1989, leaf tips near the sod in the field and near the concrete in the barn cured dark red resulting in a lower grade index compared to the top stalk position of conventionally cured tobacco.
8. Variety had no effect on grade index.

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