1975 ANNUAL REPORT

on

MECHANIZATION OF CLOSE-GROWN TOBACCO

by

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Submitted to

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Date: February 15, 1976

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1975 ANNUAL REPORT---MECHANIZATION OF CLOSE-GROWN TOBACCO

I. INTRODUCTION

This report describes the second year of research and development on Mechanization of Close-Grown Tobacco (CGT) at N. C. State University. The project, initiated in January, 1974 under support by Carreras Rothmans, Ltd., emphasizes research dealing with mechanization of direct seeding, cultural operations, entire plant harvest, and processing of harvested material. Details of the experimental program for the period January 1 to June 30 were submitted in the progress report of July, 1975. In this final report, progress reported for the first 6 months will be summarized; however, greater attention will be given to aspects related to production, harvest and processing which were completed during the last 6-month period. In addition, an assessment of progress to date with a proposed outline of research for 1976 will be presented.

II. STUDIES ON DIRECT SEEDING

A. Background. Initial studies on direct seeding were undertaken in 1974. The mecharized approach tested included steps of (1) land preparation, (2) fertilization, (3) spray application of combination herbicide-nematicide-insecticide, (4) tilrovate-bed form-seeding as one operation, (5) covering with perforated plastic, and (6) removal of plastic. While considerable progress was made in system development, problems were encounted with regards to weed control, moisture control beneath the cover, and uniformity of seedling establishment. For these reasons, the 1975 research involved further equipment development with study of various herbicides, covers, seed size and pellet process.

B. Summary (See 6-month report for complete details). Field tests were conducted to examine the effectiveness of various herbicides, covers, and seed preparation treatments used in conjunction with direct seeding of tobacco. Tobacco seed (Speight G-28) were sized to provide "large", "small" and "unsized" lots which were subsequently coated by three commercial processes. A nine-row seeder was developed to dispense the nine coated seed lots simultaneously on a pre-formed bed, with firming of seed into the upper 1/16" of soil surface. Prior to seeding, steps of land preparation, pre-bedding and fertilization were completed. Methyl bromide fumigation was compared with spray application of Enide for weed control. Following seeding, beds were covered with either perforated plastic or nylon covers.

Results showed superior control of weeds and grasses by use of methyl bromide fumigant. Plastic covers showed advantages of faster plant growth, reduced rate of water loss by evaporation, and less leaching of nutrients; but progressive and uneven drying of soil caused irregular growth. Nylon covers gave more uniform and complete germination, but required frequent irrigation to maintain adequate soil moisture. Slow growth and leaching of nutrients were major problems with nylon covers. Data were inconclusive regarding the effect of seed sizing. Differences due to pellet process were noticeable, particularly for plants grown under plastic.

III. FIELD PRODUCTION OF CLOSE-GROWN TOBACCO

A. Background. In 1974, many of the cultural operations such as fertilization, top-dressing and topping were performed by hand. Since a major objective with the CGT production system is a substantial decrease in production costs per pound of cured material, all cultural and harvest operations must be fully mechanized. The 1975 field study in the production of close-grown tobacco was therefore designed to incorporate further mechanized operations of fertilization, cultivation, top-dressing, chemical spray application and harvesting. In addition, there was a continued need to explore the yield potentials of CGT and to further produce cured material for test and evaluation.

B. Summary (See 6-month report for complete details). Three transplantings of Speight G-28 tobacco were made at the Oxford Tobacco Research Station during the period of May 22 to June 11, 1975 to provide approximately 1.5 acre. Following turning, discing and pre-bedding, pre-plant chemicals applied included Paarlan or Tillam for weed control, Mocap for nematodes, and Disyston for flea beatles and aphids. Pre-plant fertilization was applied mechanically and incorporated to provide 70-140-210 lbs/acre of N-P-K. A 2-row Powell transplanter was used to set four rows of plants per bed with 16" between-row and 10" within-row spacings.

At approximately 2 and 4 weeks after transplanting, the tobacco was cultivated with a split application of top dressing. The management schedule was designed to provide up to about 140 lb N/acre, slightly above the 1974 rate.

Off-Shoot T sucker control chemical was applied during the period July 25-August 6 while the plant was in the early flowering stage. Application rate was adjusted to provide equivalent coverage to that achieved with normal spacings. Tobacco was hand topped, and MH-30 was not applied.

C. Observations.

1. Pre-Transplant Operations. All operations prior to transplanting

were carried out efficiently. Field layout by pre-bedding was advantageous to precision of subsequent transplanting, spraying, cultivating and irrigating operations.

2. Transplanting. Alignment of the planter to achieve approximately 18" between-row spacings with two passes on the bed worked quite satisfactorily. This narrow spacing of 32" between the two rows being set, however, does pose a slight problem for the four people who drop the plants in that they each have less space in which to sit and operate. There were also some difficulty observed whenever the bed had excessive side slope. The transplanter, under such conditions, tended to track on the downhill side and it became difficult to maintain correct between-row spacings.

3. Weed and Grass Control. The combination of herbicide plus cultivation proved to be quite effective in controlling weeds during the major period of plant growth. However, the occurrence of heavy rains during the first half of July (approximately 14 inches within two weeks) created a problem in late season control, particularly for transplantings 2 and 3. Very little problem was evidenced within the beds where the tobacco had established a canopy. Between-bed grass and weed development, however, became a problem. Hand removal of the weeds were difficult without damaging the tobacco plants.

4. Growth Characteristics. Early and intermediate development of the crop was outstanding, with a good stand and healthy, vigorous growth. The occurrence of heavy rains during July, however, severely affected the late season growth and plant development. Standing water and/or saturated soil apparently caused moderate to severe root damage with many plants wilted and showing rapid leaf deterioration at the bottom of the plant. The second and third transplantings appeared to be more seriously injured,

perhaps due to the more succulent state of leaf development and rapid stage of growth. In some sections of the field, plants fell over, then resumed growth to produce a horizontal stalk segment of 8 to 10 inches length. Following topping of the plants, upper leaf development and maturation was slow and incomplete at the time of harvest. With rapid senescence of bottom leaves, harvest was made before upper leaves reached full development. Because of the unusually heavy rainfall (75 year occurrence), it is estimated that yields were reduced up to 50%. At the time of harvest, it is estimated that from 1/4 to 1/2 of the plant leaves were either lost or greatly reduced in weight due to senescence. This, including incomplete upper leaf development, seriously reduced yield.

5. Floral Initiation and Sucker Control. Flowering of plants appeared to occur in relation to time of transplanting, with the 1st transplanting flowering first, etc. Off-Shoot T was effective in controlling primary suckers; however, late-season sucker development occurred to a moderate degree, particularly for the 2nd and 3rd transplantings. This could be related to the length of time between application of the suckeride and harvest, which was longer for the later transplantings. The use of MH-30 would likely have greatly reduced late season sucker development.

IV. MECHANICAL HARVESTING AND MATERIALS HANDLING

A. Background. To fully realize the benefits of close-grown tobacco production, it is essential that harvest and handling of the crop be mechanized. Work in 1974 involved hand cutting of plants and chopping through a stationary cutter at the barn; however, this approach is suitable only for low capacity operations.

Several mechanized harvest approaches could conceivably work satisfactorily. For example, a modified forage harvester might be used to gather, cut and chop the plants and blow or convey the chopped material to the transport wagon or to large curing containers. Perhaps eventually a self-propelled harvester could straddle several rows of tobacco and cut, chop and convey even larger quantities of material to the transport wagon. Another approach might involve cutting of the stalks which are conveyed intact directly to the curing containers, suitably positioned on a pull-type trailer. For the near term, the most feasible solution would appear to be the forage harvester, modified to achieve minimal brusing and desired strip length. The chopped material can be handled efficiently by directing it into a forage wagon, having mechanized unloading. Filling of curing containers can then be accomplished rapidly at the curing site, either with direct loading from the wagon or by means of an elevator-distributor system.

Research was therefore undertaken in 1975 to:
(1) Examine the use of a modified forage harvester for high capacity harvest of CGT and (2) determine the applicability of live bed unloading from a forage wagon directly into the curing containers.

B. Materials and Methods

1. Equipment. A New Holland Model 707 tractor-mounted forage harvester was procured and various modifications made which were aimed at minimizing bruising while providing a larger strip size, changes considered important to achieving acceptable curability. The machine was equipped with nine cutter blades mounted on a 24-inch diameter cutterhead which rotated at 975 rpm at 540 rpm PTO speed. Three steel-ribbed feed cylinders provided aggressive feeding action where for forages, bruising was not of concern. By using only three blades, a strip size of 3/4 inch could be obtained. Further increase in strip size to 1 1/4 inches was obtained by reducing cutterhead rpm to 715 while increasing feed-in rate by about 10%. To reduce bruising,

new feed cylinders were fabricated having 1-inch compressible rubber coverings.

A New Holland Model 8 forage wagon was procured which provides features of front and rear unloading and variable live bed speeds. Counter-rotating "beaters" provide a loosening action for the chopped material and aid the movement of the material onto the side unloading conveyor.

2. Procedure. Prior to harvest, the modified forage harvester was tested by hand feeding tobacco plants into the machine. Cut strip size was found to be 1 1/4" and bruising appeared negligible.

Actual harvest tests were conducted from August 11 to September 10. On the first test, the machine was operated at various ground speeds and extent of bruising was qualitatively determined. Harvest rate in tons per hour was then observed for the optimal speed of harvest, at which less bruising was observed. Similarly, unloading from the forage wagon was observed during filling of curing containers.

During harvest, only one person was required to drive the tractor and operate the harvester. Starting from the sides of each 5 beds, outside rows were harvested while driving in the irrigation lanes. Successive passes were made until all 20 rows of the 5 beds were harvested.

C. Results and Discussion. Observations showed that less bruising was obtained for the higher ground speeds. This indicated that extent of bruising during cutting may be inversely related to thickness of tobacco moving over the bed knife. A ground speed of about 5 mph appeared to be most satisfactory, considering factors of bruising and control of equipment.

At a ground speed of 5 mph, harvesting rate for tobacco yielding 30,000 lb/acre green weight or 5,000 lb/acre cured weight was 12 tons/hr, assuming no turn-around time. Assuming 30% turn-around time, harvesting rate would be approximately 8.4 tons/hour. At 8 hrs/day operation for 25 days/season, a harvester could cut 1,680 tons which should yield about 280 tons of cured material per season.

No difficulty was observed in steering to harvest successive rows on the raised beds. On the first pass, the tractor wheels were positioned beside the bed, whereas on subsequent passes the wheels rode on the top of the bed. Hydraulic positioning of the header with the side-mounted harvester enabled cutting of plants to about 3 to 4 inches above ground level for all rows.

While most of the tobacco was harvested with no difficulty, two problems were encountered for plants which had fallen over after the heavy rains of July. In some cases the harvester header would miss the plants, and occasionally the crooked stalks jammed the feed-in mechanism. This latter problem required a couple of minutes of down-time to clear the machine. Another problem was that of occasional blockage of the discharge chute. Reducing cutterhead rpm could have reduced discharge velocity of chopped tobacco from the cutter housing, thereby causing a greater tendency for blockage.

Unloading of chopped tobacco into curing containers was accomplished at an unusually high rate. Within about one minute, approximately 600 lbs of tobacco could be transferred from the forage wagon directly to a curing module (3'x3'x4' size). Careful inspection of tobacco prior to and following unloading showed no apparent change in appearance or bruising which could be attributable to unloading. Since unloading rates exceed harvesting rates, two wagons should permit essentially continuous harvest provided fields are near the curing facility.

V. CURING

A. Background. In previous work, curing of the harvested material in a chopped form has involved the use of curing containers which position the strips vertically, termed curing modules. These containers during filling are positioned such that the strips fall and assume a horizontal position. After containers are filled, they are rotated to position the strips vertically. Heated and conditioned air is forced upwardly through the tobacco during the various stages of curing.

In addition to continuing the study of modular curing of CGT, the 1975 research was extended to include preliminary observations on solar curing of the chopped material. Because of high fuel and equipment costs currently associated with curing, further advances in technology which reduce these costs are urgently needed. Objectives of the study were (1) to design a simplified, lost cost curing system specifically for chopped tobacco, (2) to design a curing system which can be filled directly from a forage wagon (3) to design and test a system whereby the major source of energy for drying is solar.

B. Materials and Methods

1. Equipment. For the major portion of the curing tests, six compartmental bulk curers were used. Each curing unit has its own furnace which is thermostatically controlled. Curing compartments are 4.5 ft. wide, 6 ft. long and 8 ft. high. Curing containers used consisted of 3'x3'x4' high modules having approximately 32 ft^3 volume. At 20 lb/ft^3 each container can hold 640 pounds of harvested material. When the filled containers are positioned for curing, the fans can develop up to 3 inches static pressure to force air through the tightly packed material.

For the preliminary solar curing tests, a small solar barn was designed and constructed at the Oxford Tobacco Research Sation. The barn consisted of a curing chamber 16' long x 8' wide x 28" high connected to a fan section 4' long x 8' wide x 28" high. The curing chamber was designed with a removable fiberglas (crystal clear Lascolite) roof having 86% solar energy transmission. An expanded metal screen separated the chamber into a bottom air plenum, and a top space which could accomodate a layer of chopped tobacco of 10 to 12 inch thickness while leaving a return plenum in the space between the tobacco and the fiberglas roof. An 18-inch fan with 1/3 hp motor provided 2800 cfm air delivery at .25" static pressure. Direction and speed of the fan could be controlled by manual switching; however, on-off fan operation could be regulated manually or by automatic timer. The fan section provided both intake and recirculation dampers, which were manually adjusted to regulate drying conditions.

2. Procedures. Five curings were conducted over the harvest period Aug. 11 - Sept. 10 in which the major portion of CGT was cured in the 3' x 3' x 4' modules. Following harvest, the chopped material was mechanically transferred from the forage wagon directly into the modules. After the module was filled and capped, a fork lift was used to position the container into the compartmental curer.

Curing procedures were similar for each harvest. Initial yellowing conditions were established at 95^{o}F and 85-90% relative humidity. Progressively more drying was permitted near the end of the yellowing period (generally 48-60 hours). Leaf and stem drying conditions were established by increasing temperature at 2 to 3^{o}F/hr to 170^{o}F, with manual regulation of dampers. Complete curing was generally accomplished within five days. Following curing, the cured material was packed without re-ordering into export type shipping cartons. Subjective evaluations on curability were made to assess the combined effect of harvest-curing procedures.

Only two cures were made with the solar unit, since tobacco available for this study was limited. The procedures were as follows. The fiberglas roof was removed and tobacco transferred from the forage wagon directly into the curing unit. A rake was used to even out the chopped material into a layer of about 10 to 12 inches depth. Next the roof was replaced and the fan energized. During the first two days of curing, air flow direction was from bottom to top, i.e. up through the tobacco with essentially 100% recirculation. During the night period, the fan was run intermittently for 15 minutes each two hours. During the remaining days of curing, air flow was down through the tobacco, and dampers were adjusted for maximizing drying.

The principles of curing in the solar unit are somewhat different from that of normal flue curing. During yellowing, it is postulated that up-draft of air through the tobacco layer is essential to minimize surface drying of strips. Solar energy impinges directly on tobacco within the unit, hence can increase the temperature of the material and accelerate drying. However, movement of near saturated air up through the shreds should minimize this drying effect. On the other hand, when drying is desired, downward movement of air through the layer is considered essential. The tobacco then progressively dries from the surface downwardly and the moist air is discharged from the system after passage through the fan. During the latter stages of drying, the air is almost completely recirculated to enable development of higher temperatures. Temperatures were monitored by thermocouples positioned at various places within the curing system.

C. Results and Discussion. Cured leaf quality for CGT modular cured was qualitatively adjudged to be from poor to fair for the first three cures. During the first cure, considerable soft rot developed which seriously reduced final quality. While a part of this may be related to the unusually heavy rains of July, it was considered that excessive bruising existed during harvest with the modified machine. No doubt, the pathogenic organisms can multiply more rapidly for bruised and crushed material. The second and third cures were improved somewhat by ventilating the barns more during yellowing, however the quality of cured leaf still was below that of previous seasons in which the tobacco was cut through the stationary cutter to give leaf segments of 3" x 5.5". While it is difficult to determine exactly when or where bruising occurs in the harvesting operation, it is likely that the major part occurs during feed-in and during cutting at the moment the blade contacts the tobacco. For the last two harvests, feed-roll pressure was decreased and size of cut increased from 1 1/4" to 1 3/4" by reducing the number of blades from three to two. These changes appeared to reduce the extent of bruising, and cured leaf quality for the last two cures appeared to improve slightly. Further improvements, nevertheless, are considered necessary to achieve acceptable levels of curability.

Curing time for the modular system was generally about four to five days. In all cases the material dried completely, and the presence of stalk pieces improved air movement through the tobacco.

Results of solar curing were inconclusive, but encouraging. For the first cure a problem was encountered in that the expanded metal flooring beneath the tobacco sagged and caused by-pass of air around the sides of the layer. This was corrected and drying resumed. The cure was terminated in nine days with complete drying obtained. The second cure required about 2 weeks because of cool, rainy weather in September. Only a few pounds of material were damaged, however.

Color of the cured material was generally from tan to mahogany, and looked more like that of Burley than of flue-cured. Possibly, the cyclical variations in temperature and drying conditions caused daily drying and re-conditioning which enhanced oxidative browning. It is known that repeated conditioning and drying of flue-cured tobacco to moisture levels of 25-30% may cause tissue darkening. Also the rather extended yellowing periods for both cures due to extenuating conditions may have allowed natural senescence to proceed to the point of initiation of oxidative browning. Observed temperatures indicated that browning was not thermally initiated.

Cured weight was 240 pounds for the first curing and 250 pounds for the second curing, i. e. about 2 pounds per square foot of loading area. During a season, it is projected that 5 to 6 cures would normally be possible, provided that some supplemental energy is used during periods of cloudy and rainy weather.

Yield estimates for the crop were made at four locations during the harvest season. Effective yield ranged from 3400 to 3800 lb/acre. These values are low in comparison with those of 1974, primarily because of adverse weather conditions described earlier.

The majority of cured material for the field production of CGT was submitted to the National Institute for inclusion in certain short-term tests.

VI. OTHER PERTINENT STUDIES

In addition to the major field production study reported above, two smaller but more intensive studies were conducted in conjunction with Dr. J. F. Chaplin and C. R. Campbell to evaluate certain varietal or production factors on yield and chemistry of CGT.

In one study, sixteen varieties or selections were grown under the same set of cultural conditions described herein. In a second study by C. R. Campbell for the M. S. thesis, one variety was studied under 3 plant populations x 2 topping treatments x 4 fertility levels. Tobacco samples from both studies will be evaluated for yield and nicotine and sugar levels for various plant components.

VII. GENERAL DISCUSSION OF RESEARCH PROGRESS

Since January 1974, research in mechanization of close-grown tobacco has emphasized key problem areas important to the long-term success of the concept. While considerable progress has been made towards the solution of key problems, system development is only partially completed, new problems have been identified and new perspectives have been gained.

Field establishment of plant populations of perhaps 40,000 or more per acre is recognized as one of the greatest problem areas. With current techniques of plant production and transplanting, this operation could become more labor intensive than harvesting. The research on direct seeding and/or mechanized plant production has established the fact that a complete system which assures success in seed germination and early growth can be developed, but it will likely involve sophistication of certain steps. For example, the system must involve (1) complete weed control which at this stage demands methyl bromide fumigation (2) precision seeding with accurate spacing and depth control, and (3) moisture and temperature control. It is perhaps practical to consider development of engineered systems of plant production for transplanting as a first step towards ultimate direct field seeding. As knowledge is gained which allows predictable seedling establishment at satisfactory levels of plant uniformity, concepts and approaches can quickly be geared towards establishing field population necessary for CGT.

Mechanization of transplanting operations to achieve up to about 40,000 plants/acre has been achieved by modification of existing machines. Information is not available regarding optimal plant populations and planting layouts to achieve maximum yields (at least cost/lb) and with best quality.

Mechanization of cultural operations has involved to date a bed layout system with 4 rows of tobacco per bed. Cultivation and top dressing during early growth has been satisfactorily accomplished by simple tool-bar cultivators with mechanical fertilizer distributors metering fertilizer between rows. Spraying of chemicals has been accomplished by driving the tractor in a skip-row with extended boom to cover 2 1/2 beds on each side. Topping has been entirely by hand. It is envisioned that the bed system will require 4-wheel hi-boy equipment which straddles the beds to satisfactorily accomplish mechanical topping and sucker control with most efficient land utilization.

Results to date indicate that yield for CGT maybe at least 100% higher than that of normally grown tobacco. It is expected that further yield increases may be realized as knowledge develops on the effect of various factors such as fertilization, spacing, layout and management.

Mechanized harvest remains an area where considerable development is needed. A first attempt has been made with the modified forage harvester. While harvesting capacities are high, quality reductions due to excessive bruising appear evident. There is a great need for further development of this and other handling systems to accomodate the expected tonnage from CGT, while minimizing bruising effects.

Processing or curing of CGT in a chopped form can easily be accomplished with the modular container approach. Success, however, appears to depend greatly on the extent of bruising and tissue damage incurred during harvest. A possible alternative may be the curing of the entire plant in an intact form, packed tightly in the curing containers. Continued research is needed on more economical curing methods (e.g. solar curing of chopped material) since curing equipment costs represent one of the largest capital requirements for CGT.

VIII. PROPOSED RESEARCH - 1976

A. Mechanized Plant Production and/or Direct Field Seeding. Previous work has indicated the need for further study with emphasis on improved weed control and greater control of factors affecting uniformity of seed germination and growth under the covers. Specific objectives for the 1976 work are (1) to establish an improved bed layout system for methyl bromide fumigation (2) to improve the seeding device to enable seeding of 18 to 20 rows on the pre-formed beds (3) to improve uniformity by such factors as seed sizing, seed pre-treatment, application of water prior to covering and (4) to determine the effects of various seed treatments, coverings, etc. on uniformity of seedling development.

This work will be carried out at the Lower Coastal Plains Tobacco Research Station where better land and topography are available.

Plans are to utilize approximately 1.0 acre of actual land for mechanized seeding trials. Operations of land preparation, bed layout, fertilization and fumigation were begun during November, 1975.

Seeding trials will be conducted during February and March, 1976. At the time of each seeding, 4 seed treatments will be established: (1) unsized, (2) sized (3) unsized, treated and (4) sized, treated. Treated seed refers to a seed treatment which under lab conditions improves dark germination characteristics. All seed will be pelleted by the Asgro process. After seeding, irrigation will be applied to establish adequate water for germination beneath the cover. Two types of covers (perforated plastic, perforated plastic and nylon) will be tested in relation to each seed treatment. Three seeding trials are planned.

At transplant size, observations planned include germination percentage and size variability.

B. Field Production of Close-Grown Tobacco. Plans are to produce approximately 3.0 acres of CGT at the Oxford Tobacco Research Station using a cultural management program similar to that outlined for 1975. Objectives of the work are (1) to produce a crop under mechanized operations of fertilization, transplanting, cultivation, spraying, and harvesting, with emphasis on maximizing yield and usability of cured product, and (2) to produce experimental materials for evaluation by Carreras Rothmans, Ltd. and NCI.

If funds and time are available, mechanization of topping for CGT will be undertaken. With the bed system as currently used, a high clearance machine would be necessary, unless every third bed were skipped and a topping device developed for beds adjacent to the skip row.

Details of experimental conditions are as follows:

Location	Tobacco Research Station, Oxford, N. C.
Variety	G-28
Land Preparation	Turn, disc, harrow
Pre-bed	Field layout prior to bed forming
Soil Treatment	Multi-purpose fumigant
Other Chemicals	Mocap + Disyston + Paarlan disced or tilrovated into the bed
Fertilization	Mechanical application of 8-16-24, 1000 lb/acre
Tilrovate-bedform	Ferguson Tilrovator - bed former (57" top width of bed)
Transplanting	Powell 2-row modified transplanter. Plan for 3 transplantings to extend harvest period
Row Spacing	16"
Plant Spacing	10-12"
Plant Population	32,000-40,000 (effective)
Herbicide	ENIDE spray over at layby
Cultivation and Topdressing	4-row, 3 point hitch sweep cultivator with 2-hopper fertilizer distributor
Sucker Control	Off-Shoot T + MH 30
Insect Control	Only as needed
Harvest and Curing	Modified forage harvester with curing in compartmental chambers in chopped or intact form

C. Harvest and Processing. Because of the major problem of leaf bruising during harvest, research will be conducted to further reduce compressive forces during feed-in and impact foraces of cutting. By decreasing cutterhead rpm from 715 to 322 rpm, strip size can be increased from 1.75" to 3.9" while substantially reducing impact velocity of the blades. Failure of the material to be discharged effectively through the chute may be a problem in which case other changes to the machine may become necessary.

Harvest of the entire plant intact offers a potential alternative and could essentially eliminate problems due to high capacity chopping. Consideration will be given to a side-mounted cutter for severing the stalks just above ground level and conveying the stalks back to a trail-behind wagon. If funds are unavailable for testing this approach, at least a small quantity of tobacco can be hand cut and packed for comparative purposes.

Further development and testing of solar curing of CGT in a chopped form will be undertaken on a limited basis to evaluate more completely the potential of this approach.

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JAN. 1 - JUNE 30, 1975

I. INTRODUCTION

Research in 1974 on mechanization of close-grown tobacco placed emphasis on direct seeding, mechanized transplanting and production of test plots for evaluation. Results indicated the need for continued research and equipment development, particularly in regards to direct seeding, field production, harvest and materials handling, to provide a complete system necessary before a practical production package could be proposed and introduced at the farm level. The present report deals with further engineering developments and field experiments which are being conducted in 1975.

II. DIRECT SEEDING STUDIES

A. Background

Weed control was identified as a major problem in the 1974 study, in which a herbicide was used rather than a soil fumigant. At that time, methyl bromide was considered to be too expensive for practical use. The only herbicide available which was considered to be non-injurious to tobacco seed germination was ENIDE; but results with ENIDE were less than satisfactory, with apparent leaching and irregular control. In addition, perforated plastic as a cover excluded the possibility of secondary spray applications, in the event weed development under the cover became a problem.

Since weed control must be near perfect for success with direct seeding, further consideration has been given to the practicality of methyl bromide fumigation. Cost reductions could be achieved by re-use of perhaps a heavier-gauge material and by purchase of the fumigant in bulk. Other advantages including disease and insect control (soil) could likely make the practice economically feasible.

For the above reasons, field experiments for 1975 were planned which included examination of methyl bromide fumigant vs ENIDE for weed control and the use of perforated plastic and two gauges of nylon for covers.

Another problem experienced in the previous study was lack of uniformity of seed germination and early plant development. Evidence both in the U.S. and England indicates that variation of seedling size may arise due to factors related directly with the seed, or with the pelletting process. Seed size variability could likely influence seed or seedling performance, particularly under a range of soil and microclimatological conditions encountered in the field. Larger seed, having greater embryo size or food reserve, may "out-perform" the smaller seed. Furthermore, there may be effects due to the manner or process of pelletting. It was therefore of interest to examine the influence of seed size and pellet process on performance under field conditions.

Certain problems associated with the seeding equipment in 1974 also required attention. The major problem appeared to be lack of proper firming of the seed into the top 1/8 inch of soil. This appeared to be due to the use of too narrow press wheels which occasionally "missed" the seed, or to seed displacement to the side of the pre-formed channels.

The 1975 experiment therefore emphasized the following objectives:

1. To comparatively evaluate the use of methyl bromide and ENIDE for weed control.
2. To examine the growth and development of plants produced under perforated plastic and nylon covers.
3. To study the effect of seed sizing and pellet process on field performance and uniformity of plant development.
4. To improve equipment for direct seeding.

B. Materials and Methods

1. Equipment

(a) Methyl bromide application equipment. The previous equipment for dispensing the covering material was modified to permit methyl bromide application to the preformed 57" wide beds. This involved mounting front disc coulters, gas cylinders, dispensing tubes and drag rake to the existing unit.

(b) Fertilizer equipment. A Gandy, 3-point hitch spreader was purchased to provide more uniform placement. The equipment is used prior to bed-forming such that fertilizer is thoroughly mixed into the top 6 inches of the bed.

(c) Seeding equipment. Modifications and refinements to the seeder included increasing the number of seed drums from six to nine, chrome-plating the seed drums to achieve minimal seed coat abrasion, decreasing seed spacing within the row from eight to about two inches, re-designing channel formers to provide channels of 3" width and 1" depth with sloped sidewalls, and providing a multiple-wheel, floating press unit close coupled to the seeder. The seeding device, as before, was integrally mounted to the rear of the bed former and driven by a single floating ground drive wheel.

Seeder specifications were as follows:

Bed size: 56" across top, 4" side taper, 7" height, 18" between beds

Tractor wheel spacing: 81"

No. rows per bed: 9

Row width: 6 inches

Seed drop spacing: 1.5 - 2.0"

Seed/station: 1

Drop height of seed: 1"

Press Wheels: floating, 2" wide

2. Procedure

Variety. Speight G-28 seed was procured in 1974 from Speight Seed Co. for use in the study.

Seed Processing. An ATM Sonic Siever was used to size seed prior to pelletting to produce three lots as follows:

Size Description	Size Range (microns)
Large	500-595
Small	420-500
Unsized	354-595

Sized seed were pelletted by three commercial processes, identified as Asgro, Austrian triple coat, and Austrian greenhouse pellet, to provide nine pellet treatments.

Land Preparation. Approximately 0.5 acres of land at the Oxford Tobacco Research Station were assigned for the study. A deep sod of fescue grass was on the land during the Winter. Plans were to fully prepare the land for seeding in March, however heavy rains during January and February made this impossible. During March, the soil was turned, disced and harrowed, but considerable amount of sod was undecayed at the time of fumigation and seeding. In preparation for seeding, the land was pre-bedded, sprayed with Mocap (6 lb/acre) and Disyston (3.0 lb/acre), and tilrovated to incorporate the chemicals.

Experimental Design. On the basis of shape and layout of the field, 10 beds were available, each of about 300 ft. length. Because of the fact that optimal times for seeding were rapidly passing, the decision was made to implement two seedings, each having 5 beds as follows:

Bed No.	Treatments
1	Methyl bromide, 3 types of cover
2	Methyl bromide + chloropicrin, 3 types of cover
3	ENIDE, perforated plastic cover
4	ENIDE, Nylon (0.6 oz/yd^2)
5	ENIDE, Nylon (0.4 oz/yd^2)

Each bed, as noted previously, included 9 seed or pellet treatments.

Methyl Bromide Fumigation. Fumigation of beds 1 and 2 for each seeding was completed on March 28. In this operation, solid plastic is directly applied during soil treatment. Care was given to assuring complete covering of ends and sides of the plastic with soil. Methyl bromide was applied at the rate of 300 lb/acre; whereas methyl bromide + chloropicrin was at a rate of

500 lb/acre. Fumigation was applied to pre-formed beds and during the subsequent weekend, heavy rains washed soil away from several places along the sides of each bed.

ENIDE Application. Plans were to apply ENIDE on beds 3, 4 and 5 prior to seeding, such that the chemical could be admixed into the soil; however high winds prevented the operation. For the first seeding, therefore ENIDE 50W was applied at 16 lb/acre one day after seeding. For the second seeding, ENIDE was applied just prior to seeding.

Fertilization. Within two days of seeding, fertilizer was applied at the rate of 2000 lb/acre of 5-10-15. If seeding could not be performed the same day, the fertilizer was admixed with the soil by lightly tilrovating.

Seeding and Covering. On April 4, the first set of five beds were seeded. While winds were gusty (up to 30 mph), the operation was very successful with effective firming of seeds into the soil. Covering of the beds was completed on April 5. The second seeding, including covering, was completed April 8.

Irrigation. For the first 10 to 12 days following seeding, irrigation was applied daily for 30-40 minutes in the event of no rain. After this period, two light irrigations per day were applied until germination appeared complete. Irrigation during latter stages prior to removal of covers were less frequent and only as needed to assure adequate moisture for plant growth.

Removal of Covers. On May 8, perforated plastic covers were removed with nylon covers removed on May 12.

C. Results and Discussion.

Prior to discussing results and observations, it is important to note that several conditions which developed during the course of the study prevented a quantitative evaluation of effects. These factors will be discussed under the appropriate headings below. For this reason, only qualitative observations are presented. Nevertheless, many of the observations provide important information which should be useful in subsequent work on direct seeding.

Weed Control. In no case was weed control completely satisfactory. For the methyl bromide treatments, there was evidence that leakage of the fumigant occurred from the sides of beds, thereby decreasing the concentration and reducing effectiveness. In certain areas of the beds treated, almost complete control was achieved. Quite interestingly, control was markedly more effective for portions of beds covered with perforated plastic subsequent to treatment than those portions covered with nylon. No satisfactory explanation for this can be given, since effectiveness should be independent of the subsequent covering. It is known that methyl bromide should provide essentially perfect control, so lack of control must be traced to fumigant leakage. During treatment and covering of adjacent beds with solid plastic, it was noted that the rear tire occasionally punctured the solid plastic, since the beds were separated by a distance equal to the tire width and slight steering error permitted the wheel to ride over the already laid plastic. Although these holes were covered with soil, heavy rain during the weekend following treatment uncovered certain holes in the plastic and some portions along the side of the beds. This problem, in practice, can be overcome simply by fumigating in two steps, first fumigating alternate strips separated by the width of a bed then fumigating the bare lanes after removal of plastic from the first treated beds. Also, it appears that fumigating prior to bed forming will provide better coverage on the sides which are less affected by rain.

Three major weeds were noted in this study: crabgrass, nutgrass and ragweed. In all cases under the perforated plastic, where the soil had been treated with methyl bromide, there was almost complete absense of ragweed and nutgrass but with spotted growth of crabgrass. However under nylon, there appeared to be a large amount of all three weeds. It was suggested that the combination of methyl bromide followed by ENIDE after seeding may have provided complete control.

ENIDE treated beds with both incorporation or surface application showed very effective control of crabgrass, but poor control of nutgrass and ragweed. Some injury or stunting of nutgrass was noted, but essentially no effect observed on the ragweed.

Tobacco Seed Germination and Early Growth. As in 1974, a problem in control of moisture was evidenced under the perforated plastic. While soil moisture was adequate initially, progressive drying was noted which undoubtedly interfered with germination. Also, it was observed that many of the pellets did not dissolve due to inadequate water. Where water did penetrate the cover, germination was excellent and plants grew rapidly. It appeared that free water was required to dissolve the pellets, suggesting either water application during seeding or irrigation following seeding, but prior to covering with perforated plastic. It also would appear advantageous to cover with solid plastic, then perforate after germination is complete.

Germination under nylon (both gauges) appeared uniform with near perfect stand; however growth was very slow in the early stage. It was not possible to obtain data on germination percentage until after removal of the cover, but then a rain on the evening the covers were removed caused bed erosion which covered most of the small seedlings with soil. For the plants which had been growing under perforated plastic, this was not a problem since the plants were larger. This portion of the study definitely confirmed the importance of free water (which easily penetrated nylon during irrigation) on pellet breakdown and seed germination. While the nylon proved advantageous in regards to water penetration, the irrigation schedule likely provided an excess of water which caused leaching of nutrients. Not only were plants smaller due to lower temperatures, but they tended to yellow indicating nitrogen deficiency. Here the evidence suggested the need for applied water in amounts just sufficient to prevent surface drying and for a nutrition schedule which readily compensates for leaching.

No differences in germination or growth rate were detectable due to the two weights of nylon cover. The heavier gauge (0.6 oz/yd^2) was found preferable, however, since the lighter weight material tended to stretch and tear during application.

Tobacco plants growing on methyl bromide treated beds appeared in general to have more vigor and better color than plants growing on ENIDE treated beds, when comparing growth under the same type of cover.

Effect of Seed Size and Pellet Process. Because of the above factors which negated quantitative observations, it was difficult to reach firm conclusions regarding the effects of seed size and pellet process. However, during the period of observation, there appeared to be some indication that the larger seeds were germinating better and growing faster than the smaller seeds. Differences due to pellet process appeared more noticeable among plants grown under perforated plastic than those grown under nylon. Qualitative rankings would place Asgro 1st, Austrian triple-coat 2nd, and Austrian greenhouse pellet 3rd.

In order to further establish the effects of seed size and pelletting process, studies have been initiated in the Southeastern Plant Environment

Laboratories (Phytotron) at N.C. State University. In addition to germination studies over a range of temperature, plant development during the early stage of growth will be functionally evaluated for various day/night temperature conditions.

D. Conclusions

1. On the basis of the two years research, ENIDE does not provide control of weeds to the degree required for direct seeding. Under ideal conditions, crabgrass control is effective; however other weeds such as nutgrass, ragweed, etc. are not controlled.
2. At this stage of research, use of methyl bromide appears to be the logical approach to weed control. The mechanized system should include application on flat, level land rather than on beds to obtain improved sealing along the sides. Treatment of alternate beds appears preferable to treatment of all beds at one time.
3. Pelletted seed must have sufficient water to dissolve the coating to obtain germination. This is no problem with the use of highly porous covers, such as nylon, but can be a problem with the use of solid or perforated plastic. Where pelletted seed had adequate water, germination was high and relatively uniform for sized seed lots.
4. Plant growth under perforated plastic is considerably faster than under nylon and leaching of nutrients does not appear to be a problem. Improved performance is indicated by a system including the steps of seeding, establishing the proper soil moisture, covering with solid plastic, perforating after germination is complete, and removal of plastic when probability of frost is low.

5. Use of nylon as a cover minimizes the possibility of thermal damage, but poses the additional problems of reduced growth rate and greater possibility of leaching. Frequent and light irrigations are necessary to maintain adequate moisture for germination. Additional applications of nitrogen after germination appear necessary to sustain rapid plant growth.

6. Effects of seed sizing and pellet process on uniformity of seedling. development are inconclusive. Further work under controlled conditions is necessary to establish the nature of effects.

7. Equipment for drilling pelletted seed has been developed which can establish plant populations to any desired level. Wtih one simple seed dispensing drum, row spacings as close as 2 inches can be achieved while providing any desired within-row spacing. Ultra-high plant populations of several hundred thousand stations per acre could easily be achieved.

8. Timing of operations remains of critical concern, particularly in regards to achieving a crop which can be harvested over a five to six-week period. Experience here suggests that many operations such as land preparation, fertilization and fumigation should be performed during fall or early winter. Then late winter and early spring seedings can be introduced as weather permits.

III. FIELD PRODUCTION OF CLOSE-GROWN TOBACCO

A. Background

Production of close-grown tobacco at Oxford in 1974 was only semi-mechanized, i.e. only certain operations such as land preparation, bed-forming, pre-plant chemical application and transplanting were mechanized. Other operations such as pre-plant fertilization, top-dressing, sucker control and harvesting were by hand. The need exists to fully mechanize all operations, where possible. With improved techniques for fertilization, cultivation and pest control, yield per acre should be further improved.

For the above reasons and to provide material for examination by Carreras Rothmans Ltd. and NCI, a study was undertaken to produce approximately 1.5 acre with incorporation of further mechanized operations of fertilization, cultivation, top-dressing, chemical spray application and harvesting. (The latter aspect will be considered separately under Section IV).

B. Materials and Methods

In the following discussion of experimental procedures, note should be made that certain modifications from the original research plan were incorporated.

Three field plots were assigned for the study at the Oxford Tobacco Research Station. In early March, Speight G-28 tobacco was seeded in conventional plant beds for the project. Land preparation of the various plots which included turning and discing also was performed in March.

About two weeks prior to transplanting, the plots were again disced, and pre-bedded with listers to lay out the beds for transplanting. The layout scheme provided for an irrigation lane between each 5 beds.

Pre-plant chemicals were applied as follows:

(a) for weed control - either Paarlan or Tillam at recommended rates of 1 qt/acre or 2.7 qts/acre respectively.

(b) for nematodes and wireworms - Mocap at 6 lb/acre.

(c) for insects (flea beatles and aphids) - Disyston at 4.0 lb/acre.

Following spray or granular application of chemicals, the beds were tilrovated and shaped.

Pre-plant fertilization was applied mechanically to the pre-formed bed with a Gandy applicator to achieve approximately 70 lbs of N, 140 lbs of P, and 210 lbs of K per acre. Fertilizer was admixed with the soil again by tilrovating.

Transplanting was carried out during the period of May 22 to June 11 to provide staggered plantings and extended harvest. A Powell 2-row transplanter was procured and modified slightly to permit off-set planting on the bed. A second pass on the same bed in the opposite direction enabled setting of four rows per bed with rows at 16" spacing and plants 10" apart within rows. The transplanter provided water during transplanting, which appeared to reduce transplant shock over previous work in 1974.

For cultivation and topdressing, a 3-point hitch distributor-cultivator was devised. Fertilizer was placed between each pair of outside rows on the bed, with simultaneous cultivation by means of sweeps. Two top dressings were applied to each transplanting, at approximately two and four weeks following transplanting.

The management schedule provided approximately 150 lb of N, slightly higher than the 1974 work. During the middle of July, approximately 12 inches of rain fell within a week, which no doubt leached a large portion of the applied top-dressings.

The following table indicates the schedule of operations performed for the four transplantings up to July 1st, 1975.

Operation	Dates Trans. 1	Trans. 2	Trans. 3	Trans. 4
Land Prep.	3/3-3/7	4/1-4/15	3/3-3/7	4/15-4/30
Prebed	5/8	5/26-27	5/26-27	6/3
Pre-plant Chemicals	5/8-9	5/26-27	6/3-4	6/3-4
Fertilize	5/21	5/27	4/3-8	6/4
Transplant	5/22-23	5/29-30	6/6	6/11
1st Cult. & Topdress	6/10	6/23	6/30	6/30
2nd Cult. & Topdress	6/23	6/30	———	———

C. Observations

At the time of this report, all field plots are gradually recovering from heavy rains during mid-July. The earliest transplanting appeared to suffer least damage with progressively more damage for the later transplantings. Tobacco is now nearing the topping stage with harvest expected to begin around August 10.

While it is too early to estimate yield at this time, transplantings 1 and 2 should likely reach 5000 lb/acre. Transplantings 3 and 4, more severely damaged by excess water, will do well to achieve 3500 lb/acre. Complete data on yield for the various transplantings will be presented in the annual report.

IV. MECHANIZED HARVEST AND PROCESSING.

A. Background

To realize the potential benefits of close-grown tobacco production, an efficient harvest and handling system must be available. Harvest weight per acre is expected to be from about 12 to 18 tons, or at least double that of conventionally grown leaf.

Previous work in 1974 has involved hand cutting of plants and chopping through a stationary cutter at the barn; however this approach is suitable only for low capacity or small operations. Mechanized field harvest is necessary for large production units. The most feasible solution for the near-term is a forage harvester, modified to achieve minimal bruising and desired strip length. These machines are capable of harvesting forage at rates up to 25 tons/hr; however, it is not known what capacities may be possible with tobacco. If 10 tons/hr can be achieved, a one-row harvester should be able to harvest up to 150 acres within six weeks.

At this harvest rate, filling of curing containers at the curing facility appears more efficient than field loading. Conventional forage wagons with live bed unloading may enable rapid movement of the chopped material directly into containers by means of an elevator-distributor located at the curing site.

For the above reasons, research was undertaken to investigate the use of a modified forage harvester for high capacity harvest and to develop further the materials handling system for rapid filling of curing containers.

B. Materials and Methods.

1. Equipment. A New Holland Model 707 tractor mounted forage harvester has been procured and design changes made which should improve performance by minimizing bruising and providing a larger strip size. Prior to modifications, the harvester was equipped with 9 cutting blades and provided a maximum strip size of 3/4 inch, by the use of only three blades. Feed rolls having serrated

steel ribs provided an agressive feeding action for forage, where bruising was not of concern.

Modifications were as follows: (1) the number of blades were reduced to three (2) the three feed rolls were removed and new rolls fabricated having a 1-inch compressible rubber covering, and (3) feed-in rate was increased about 10% while cutter rpm was reduced by about 10%. These changes permit a larger strip up to 1 1/4 inch, while reducing feed-in bruising. Plans are to further reduce the cutter rpm to obtain larger strips, if satisfactory operation is realized during actual harvest tests.

A New Holland Model 8 forage wagon was procured to permit observations of materials handling at high capacity in the filling of the curing containers. This wagon has features of front and rear unloading and variable live bed speeds. "Beaters" counter-rotating provide a loosening action to forage; but how well they will work for tobacco is unknown.

2. Procedure. While harvest has not begun, the following procedure is planned. Harvest of the tobacco is planned for a 5-week period. One day per week, a portion of the field tobacco will be harvested. During, the first week of harvest, care will be given to establishing the best operating ground speed with observations of extent of bruising. During harvest, one tractor will be used for the harvester (side mounted), and also pull the receiving wagon. Since the quantity of harvest is not great, only one wagon will be used. At the curing facility, the wagon will discharge the chopped tobacco onto a conveyor where the material

is elevated and distributed directly into the curing containers (modules), each holding about 600 pounds. The container will be capped, lifted and rotated 90 degrees, then positioned by fork lift into the curing chambers.

Curing will follow the normal schedules for flue-cured leaf. Following curing, the cured material will be packaged in export type shipping cartons for storage.

Observations during harvest and curing will include machine performance, extent of bruising, rates of harvest and unloading to the filling apparatus, curing conditions, yield, etc.

Cured material will be submitted to NCI for biological tests, with samples retained for certain chemical analyses or other evaluations by N.C. State University or Carreras Rothmans.

1976 ANNUAL REPORT

ON

MECHANIZATION OF CLOSE-GROWN TOBACCO

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