1976 ANNUAL REPORT

ON

MECHANIZATION OF CLOSE-GROWN TOBACCO

by

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1976 ANNUAL REPORT --- MECHANIZATION OF CLOSE-GROWN TOBACCO

I. INTRODUCTION

This report describes the third year of research and development on Mechanization of Close-Grown Tobacco at N. C. State University. The project, initiated in January 1974 under support by Carreras Rothmans, Ltd., emphasizes research dealing with mechanization of transplant production and direct seeding, cultural operations, entire plant harvest and processing of harvested materials. Details of the experimental program for the period January 1 to June 30, 1975 were submitted in the progress report of July, 1975.

II. MECHANIZED TRANSPLANT PRODUCTION

A. Background. Previous research indicated the need for improved weed control and greater control of factors affecting uniformity of seed germination and growth. For mechanization of successive operations, a narrow-bed system whereby the tractor straddles the bed is indicated. Further research on improved bed design has been indicated to enable complete fumigation of the "planting zone", without contamination during seeding. Prior laboratory studies have shown advantages due to seed sizing and method of coating, however field results have been inconclusive.

Specific objectives for the 1976 research were (1) to establish an improved bed layout system for methyl bromide fumigation and seeding (2) to improve the seeding device to permit simultaneous seeding of 18 to 20 rows on the pre-formed beds and (3) to study the effect of seed sizing and pre-treatment on uniformity of seedling development under various covers.

B. Materials and Methods. Approximately 1.5 acres were used for this study at the Lower Coastal Plains Tobacco Research Station at Kinston, N. C.

In order to achieve effective fumigation and subsequent seeding into a weed-free zone of the treated bed, a bed layout system was designed having the following characteristics:

Center-to-center tractor wheel spacing-------86"

Effective width fumigated--------------------60"

Width of bed tilrovated----------------------56"

Width of formed bed prior to seeding---------48"

Width of seeded zone-------------------------36"

This design permitted fumigation of adjacent beds with adequate clearance to avoid damage from tractor wheels, and allowed bed-forming and seeding into the 60" fumigated zone without mixing with untreated soil.

Equipment used was essentially the same as in 1975, but with modifications to achieve the above bed design and with a larger number of rows. Fumigation equipment was widened to fumigate an effective 60" strip and improved to obtain more accurate stability and depth control. The seeder was modified to provide 18 rows on the pre-formed bed, in four bands. Two bands were designed to provide 4 rows at 2" between-row and 1 1/2" within-row spacings. The other two bands provided 5 rows at 1 1/2" between-row and 1 1/2" within-row spacings. The bedformer and seeder attachment were further designed such that each band of seeds were firmed into a channel 1" deep and 7" wide, separated by 3" ridges. In this manner, the coverings were supported above the germinating seeds.

Speight G-28 tobacco seed procured in 1975 were separated into various size groups using precision sieves (354, 420, 473, 500, 532, and 563 micron respectively) and an ATM Sonic Sifter. Since seed held on the 473 micron sieve constituted more than 50% of the seed population, these seed were selected as the "sized" lot. Sized and unsized lots were treated by soaking in water for 48 hours in the presence of light followed by drying to a constant weight under room conditions. Preliminary tests had established improved dark germination for seed pre-treated in this manner.

Tobacco seed were coated by Asgrow Seed Co. to provide four seed lots (treatments) for the field study:

Lot No.	Description	% Germination
1	G-28, sized, untreated	91
2	G-28, sized, treated	95
3	G-28, unsized, untreated	89
4	G-28, unsized, treated	93

Field work was initiated during November, 1975. The land was disced, turned and "shaped" to form a 40'-wide raised bed between each irrigation line. Fertilizer was applied with a Gandy distributor at the rate of 2400 lb/acre of 12-6-6 to 4' bands between the wheels which outlined the beds (81" center-to-center). The fertilizer was mixed into the upper three inches of soil with a spring tooth harrow. Methyl bromide was injected into the soil at the rate of 300 lb/acre and covered with solid plastic (1.5 mil). All operations were conducted under favorable soil moisture and temperature conditions. Twenty-two beds of 200-ft length and 12 beds of 180-ft length were fumigated prior to inclement weather.

The beds remained covered during December and January. Preparations were made to begin seeding in early February. Plans were to conduct three seeding trials with 12 beds for the first trial, 10 for the second and 12 for the third. With the exception of seeding No. 2, sufficient beds were available for three replications of each of the four seed treatments with a seed treatment for each bed. Dates of the three seeding trials were No. 1 - February 9-10; No. 2 - February 16; and No. 3 - February 26-27.

Procedures for each of the three seeding trials were essentially the same, with the exception of watering method. After removal of the solid plastic, the beds were tilrovated and seeded. Granular DiSyston was applied by hand at the rate of 9 oz. of 15% granulated per 100 yd^2. Wheat straw mulch was hand applied at 3/4 bale per 100 yd^2. Next, sprinkler irrigation was applied to provide about 1/4"-3/8" of water during the late afternoon. For the third seeding, a portable water wagon with sprinkler boom provided more uniform watering. Two types of covers were applied to each bed: perforated plastic (3/8" holes on 3" centers) and perforated plastic plus .5 oz/yd^2 nylon. Following covering, irrigation was provided only to prevent heat damage on unusually warm days when outside temperatures reached about 85 F.

Removal of covers for the three seedings were made on March 29, April 5, and April 15 respectively. At this stage plants were about 2" to 3" tall and pushing up against the covers. After removal of covers, the beds were topdressed with 16-0-0 at the rate of 750 lb/acre. Zineb (fungicide) was applied at approximately weekly intervals to control blue mold. Irrigation was applied as necessary to maintain proper growth. On one occasion, irrigation was used for frost prevention.

C. Results and Discussion. In order to evaluate the effect of the various experimental factors, an extensive sampling study was conducted. Ten sampling sites were located for each bed, using statistical randomization for the first site and with equal spacing for remaining sites. At each sampling site, two samples of tobacco plants were collected from the two central bands which represented two plant densities. The collection area was 12" long x 6" wide.

Collection and measurement of plants was as follows. Plants were carefully cut at ground level, immediately placed in plastic bags, then stored temporarily in ice chests to minimize weight changes prior to taking measurements. Collected plants were taken to the laboratory and measurements made of number of plants, individual plant weight, stem length, stem diameter and extended length.

The effects on germination percentage due to seed treatment, plant bed cover, and seeding density are shown in Tables 1 - 3. Seed treatment appeared to improve germination percentage for sized seed; however, the reverse was observed for unsized seed. In all seedings, perforated plastic plus nylon (overlay) gave improved germination in comparison with perforated plastic. This may likely be due to a reduction in moisture loss from the beds having the double cover and to improvement in microclimate during germination. A slightly higher percentage of germination was noted for the lower seeding density, although this is probably not significant.

The effects of seed treatment, seeding density and plant bed cover on various transplant parameters are shown in Table 4. No significant difference in transplant size was observed between seed treatments except for the unsized treated seeds. The plant size in this group was slightly larger due to the lower germination percentage or lower plant population. The plant size in the low seeding density group was slightly larger than that in the high seeding density group, and plants covered with plastic were also slightly larger than plants covered with plastic plus nylon. The plant size was affected mainly by plant population.

Coefficients of variability for various transplant parameters are shown in Table 5. In general, plants in seedings 2 and 3 were more uniform than plants in seeding 1. However, there was no significant difference in plant uniformity between seed treatments, between seeding densities, and between plant bed covers. Plant size expressed in extended length or stem diameter was more uniform than expressed in weight or stem length.

Apart from basic differences existing among seeds (size, density, vigor, etc.), several factors were noted which significantly affected the variability of seedling development. The largest single effect appeared due to variations in soil moisture, which likely also influenced soil temperature. At the time of seeding, soil moisture variations were observed which continued throughout the season. It was noted that low spots of the field which had poor drainage allowed accumulation of water beneath the fumigated beds. The critical importance of uniform drainage of water from the field during the period between fumigation and seeding was evident. Furthermore, overhead irrigation was found to contribute to additional soil moisture variability, either by the fact that the system does not provide uniform application or by the secondary effect due to wind. This observation led to the test of a portable watering system for greater uniformity in applying water immediately following seeding and during latter stages of growth.

Other factors which are considered to have influenced variability include (1) seed displacement due to impact of water droplets from sprinkler irrigation, (2) differences in nutrient availability due to differential leaching at various locations as a result of non-uniform watering, (3) variability in application of wheat straw mulch (this operation was greatly influenced by wind and by person applying the mulch), (4) height of cover over germiating seed or young seedling, and (5) variability in seed placement due to slope of beds, wind, and lack of precision in seeding.

Observations relating to overall progress in system development including timeliness of operations, equipment performance, weed control, etc. were presented in the earlier report.

III. EFFECTS OF TRANSPLANT VARIABILITY

A. Background. It is well known that tobacco transplants vary over a wide range in terms of size and style, and it is fairly well accepted that final yield and quality must be related to the uniformity and quality of transplants. The latter two factors apparently lack definition, hence field results are rather inconclusive on the effects of transplant "size" on final yield.

This study was initiated to obtain preliminary data and observations related to the effect of transplant variability on growth characteristics and final yield.

B. Materials and Methods. Five groups of seedlings were selected on the basis of extended length (small, 15-20 cm; medium, 22-27 cm; large 30-35 cm; V2, 50% small and 50% large; V3, 33% small, 33% medium and 33% large). Six, 17-plant rows of each plant size group was transplanted into each of three field plots, for a total of 90 rows. The central stem heights for each plant was measured at weekly intervals from transplanting until flowering. Tobacco leaves were primed six times and cured leaf weight was measured for each plant.

C. Results and Discussion. Measurements of the stem height during growth to flowering showed that smaller plants remained shorter while larger plants remained taller. However, as shown in Table 6, the larger transplants did not result in higher yields. The coefficients of variability for stem height for groups V2 and V3 were higher in the beginning. However, they decreased as the plants grew and the final cured yields in groups V2 and V3 were as uniform as for the other groups. These results indicated that uniformity of stem height and final yield are not affected by the initial transplant uniformity, measured in terms of extended length of transplant. Qualitative observations of cured tobacco indicated that groups V2 and V3 gave greater variability of leaf characteristics. Further research will be necessary to confirm this, however.

VI. DIRECT FIELD SEEDING

A. Background. Previous work in England has shown trends toward a continued increase in dry matter yield with increasing plant populations (direct seeded). It was of interest to note whether similarly high and increasing yields would be obtained under U. S. conditions. An objective of close-grown tobacco is to maximize yield consistent with production of a tobacco material suitable for cigarettes. The effect of plant population under direct seeding is of great importance since very high populations can easily be established with little additional cost.

B. Materials and Methods. Following collection of samples from the field study on mechanized transplant production, a study was conducted to observe the general trend of effect of plant population on yield. Seven plant populations, ranging from about 7000 to about 1/2 million or more (unthinned) plants/acre, were established by thinning randomly selected plots of about 20' length. Sixty-three plots provided three replications of each plant population for each of three harvest dates. Following thinning of the plots, the beds were topdressed with 15-0-14 to provide 50 lbs. of N/acre. Irrigation was provided as necessary to maintain normal growth.

Three harvest were made during June. Plants were handcut with machetta, tied to sticks, and cured in conventional flue curing barns.

C. Results and Discussion. Cured weight data indicated that total yield of leaf plus stalks continued to increase (up to 10,427 lb/acre) as plant population increased up to 1/2 million plants/acre (Table 7). Ratio of cured weight to green weight was fairly constant at about .12 to .13, which is lower than that of previous work (.17) with transplanted tobacco harvested in a similar manner but grown under more typical tobacco soils.

It should be pointed out that these results are very preliminary, because of soils and culture. While quality of material produced was not of major interest, representative lots of cured tobacco will be converted into sheet and further evaluated. In order to observe potential for dry matter accumulation at the very high seeding density, other small plots were harvested over a 7-week period. Dry weight yields approaching 15,000 lb/acre were observed.

V. FIELD PRODUCTION OF CLOSE-GROWN TOBACCO

A. Background. During 1974 and 1975, a cultural management program was developed for the production of close-grown tobacco. This program, from land preparation to harvest, emphasized mechanized operations. In 1975, the crop looked excellent until July and the occurrence of about 16 inches of rain. Leaf quality suffered greatly and yields were reduced. Also in 1975, a modified forage harvester was tested for use in harvesting the entire plant with CGT, with handling and curing in a chopped form. Extensive bruising caused problems in curing to an acceptable quality.

Plans were developed to produce in 1976 approximately 3.0 acres of CGT at the Oxford Tobacco Research Station using a cultural management program similar to that outlined in 1975. Objectives were (1) to produce a crop under mechanized operations of fertilization, bedforming, transplanting, cultivation, spraying and harvesting with emphasis on maximizing yield and usability of the cured product and (2) to produce experimental materials for entry into the NCI test program and for other evaluations by cooperating companies.

B. Materials and Methods. Experimental procedures followed the same basic plan as used in 1975. Discing, turning and harrowing operations were completed in March and April. Pre-plant chemical applications included Paarlan (weed control), Mocap (nematodes and wireworm control) and DiSyston (systemic insecticide).

Pre-bedding in early May was made to provide 84" center-to-center bed spacing with an irrigation lane between each 5 beds. Fertilization was applied mechanically to the beds using a Gandy distributor. Rate of fertilizer application was 1000 lb/acre of 8-16-24 to provide about 80 lb/acre of N. Beds were tilrovated to a four-inch depth following fertilizing.

Transplanting (Speight G-28 variety) was carried out during the period of May 11 to June 2 to provide staggered plantings and extended harvest. The same transplanter was used as in 1975 to provide 4 rows/bed with 16" spacing between rows and 10" spacing with rows (39,000/acre effective plant population).

At about two and four weeks after transplanting, the tobacco was cultivated and topdressed to bring total N to 140-150 lbs/acre. Post-plant fertilizer consisted of 15-0-14 for the first topdressing and 16-0-0 for the second topdressing at roughly equal amounts per application.

Sucker control chemicals used consisted of Off-Shoot T applied in the early flowering stage and MH-30 applied following topping. Recommended rates were applied but with an increased number of nozzles to obtain effective coverage of the close-spaced rows. Plants were topped by hand to leave 15-17 leaves/plant.

C. Results and Discussion. Up to the time of beginning harvest, field production of CGT looked better than any of the previous years. Weed control was excellent with only an occasional weed. Sucker control was generally good; however, an occasional side row on a bed appeared to have received inadequate chemicals. This may have resulted from a steering error or a difference in width of the irrigation lane. Leaf development was excellent; however, leaf deterioration due to low light levels occurred at the bottom of the plant with a loss of 4 to 8 leaves prior to harvest. Upper leaves filled out and matured to form almost normal sized leaves.

The field production system with four rows per bed at 16" spacing has worked quite well with no insurmountable problems noted. Field preparation, bed forming and transplanting can be accomplished easily. Because of the narrow rows, some minor difficulties have been noted in cultivation, particularly in regards to being able to cultivate at normal speeds without plant injury. Small rolling cultivators could possibly offer improvements in this area. High clearance topping and spraying equipment would be necessary to complete mechanization of field production, since skipping every third bed would reduce field efficiency.

VI. MECHANIZED HARVEST AND PROCESSING

A. Background. In 1975, tests were initiated on mechanized harvest and handling of CGT using a modified forage harvester with forage wagon. While measures were taken to reduce bruising (reduced cutterhead rpm, reduced number of blades, less vigorous feed-rolls), cured leaf quality was considered to be reduced appreciably due to continued excess bruising.

Plans for 1976 were made to continue studies on the "modified harvester approach" with objectives (1) further reducing bruising during the harvest operation, and (2) comparing the curability of forage machine chopped, stationary cutter chopped, and whole plant tobacco from the CGT field study. By appraising the extent of physical and chemical damage due to the forage harvester approach, it may be possible to measure progress in machine development or harvest technique in subsequent tests.

B. Materials and Methods. In order to reduce bruising during harvesting, further modifications to the machine were made. Cutterhead speed was reduced from 715 to 445 rpm at 450 rpm PTO speed. A fan was installed behind the harvester with an air duct connected to the harvester's discharge tube to assist delivering chopped material to the wagon. By using only two blades on the cutterhead, a cut-strip size of 2.8" could be obtained. However, material occasionally blocked the harvester's discharge tube during harvesting. This indicated that the strip size of 2.8" was too large for the tube. Therefore, three blades were used to obtain a strip size of about 1.9 inches.

Harvest and curing tests were conducted over an eight-week period. The procedure for harvest was as follows: At least one day per week, a portion of the field tobacco was harvested, trying to achieve near optimal leaf development and maturity. One lot of tobacco was machine harvested and the chopped material loaded directly from the wagon into curing modules of 3' x 3' x 4' size. A second lot was hand harvested with machettas and the plants fed through a stationary cutter to provide 3" x 5" strips or segments. These were conveyed into the same type curing modules. A third lot was harvested as whole plant and bulk cured in racks. Curing procedures followed the typical schedules for flue-cured tobacco. Following curing, the dried material was packed in export-type shipping cartons for storage.

C. Results and Discussion. Inspection of forage harvested tobacco indicated that excessive bruising was still present with strip sizes of 1.9 inches. Much of the bruising damage was attributed to the agressive feeding mechanism required by the machine for continuous high-capacity operation, impact bruising during cutting, and further abrasion during high velocity transport through the discharge duct. Tobacco which was barn chopped through the stationary cutter showed only minor evidence of bruising, and whole plants packed into racks also showed minimal bruising.

Quality of cured materials were adjudged to be better than that of previous years, probably due to better growing conditions and improved production know-how. Tobaccos which were cured in a whole plant form or barn chopped had excellent cured leaf appearance, whereas the forage harvested tobacco showed evidence of bruising. As shown in Table 8, forage harvesting appeared to depress sugars and alkaloids in comparison to the other harvest methods. Leaf nicotine values generally ranged between about 2.0 and 2.5 for whole plant or barn chopped tobaccos however forage chopped material gave nicotine values between 1.0 and 1.5. These reductions could be associated with excessive bruising during harvest.

Approximately 2000 pounds of barn chopped material was submitted to the National Cancer Institute for biological tests. Other select samples have been provided to a cooperating company for laboratory tests and conversion into sheet. It is hoped that commercial evaluations will enable determination of relative acceptability of whole plant, barn chopped and forage chopped materials.

For the first two harvests, yield estimates based on weight of approximately 3000 plants showed effective yields of 7500-8000 lb/acre (5500-6000 lb/acre actual). Later harvests likely gave lower yields due to the fact that they were from later transplantings and were harvested after optimal maturity and suffered more bottom leaf loss.

VII. SOLAR CURING OF CHOPPED CGT

A. Summary. Studies on solar curing were continued along the same lines as reported for the 1975 tests. In order to improve the uniformity of air flow through tobacco, the fiberglass roof of the solar curing unit was modified such that it could be mounted airtight to the curing chamber, and two air control dampers were installed at the end of the chamber opposite the fan section. Two portable electric heaters, with a capacity of 1.2 kw each and with the thermostat setting at about 75 F, were used to increase the drying at night. Three cures were conducted during the season. Chopped material with 1.9" cut size was unloaded directly from the forage wagon to the solar unit. During the first two days of curing, air was directed upwards through the tobacco to reject excess solar heat and cool the tobacco. Afterwards, air flow direction was reversed to utilize solar energy for drying. Temperatures were measured at various locations within the system. Air temperatures up to 120 F inside the chamber were detected. About 9 to 15 days, depending on weather, were required to dry the tobacco. The quality of cured material was improved over the 1975 tests because of less bruising, more uniform air flow through the tobacco and improved drying. Evaluations of the cured materials are underway.

VIII. RESEARCH PLANNED FOR 1977

A. Mechanized Transplant Production and/or Direct Field Seeding. Continued study is indicated to further improve seedling uniformity and to establish criteria related to seed germination and early growth. Based on results of the 1976 work, objectives for 1977 will include the following (1) to determine the effect of seed sizing and pre-treatment prior to coating on seedling uniformity (2) to investigate the use of a hydromulch for reducing moisture loss from the seeded beds and for enhanced germination and (3) to further observe portable watering as a means of reducing soil moisture variations. In addition, it will be of interest to examine the feasibility (prospects and problems) of late season direct field seeding with and without protective nylon covering. With some success in plant establishment, various plant populations will be carried to a harvest stage.

B. Field Production, Harvest and Processing. Further mechanization research will be conducted at the Oxford Tobacco Research Station having the following objectives (1) to determine comparative yields and quality of four distinct layout systems -- 4 rows on bed, 3 rows on bed, 3 rows transplanted flat, and twin-row transplanted flat (Canadian 2-row layout), (2) to investigate equipment requirements for transplanting, cultivating, topping and harvesting tobaccos produced by the different layout systems. It is postulated that a layout (perhaps similar to the 3 row) between the 4 rows on bed and the twin-row systems may provide improved quality without serious yield reduction. This could arise due to improved light reception and reduced bottom leaf deterioration. Furthermore, the effect of two practical populations and two topping heights (normal and low) will receive attention.

Two types of topping equipment will be evaluated in relation to the various layouts, a tractor-mounted 2-row topper and a high clearance 4-row topper. The latter will be studied particularly in relation to the 4 rows on bed layout, since this system will require high clearance topping equipment for most effective land utilization.

Because of potential problems of maintaining quality with the modified forage harvester approach, further attention will be given to harvest and curing in whole plant and barn chopped forms. A pull behind stalk harvester developed for burley tobacco will be tested for stalk cutting of CGT. Tobaccos will be cured in both bulk racks and curing modules.

Table 1. Effect of seed treatment on the germination percentage of tobacco seed.

Seed Treatments	Seeding No.			Average
	1	2	3	
Sized untreated	64.5	76.1	75.7	72.1
Sized treated	80.7	70.8	80.0	77.2
Unsized untreated	78.4	69.8	75.1	74.4
Unsized treated	62.6	69.4	71.5	67.8

Table 2. Effect of plant bed cover on the germination percentage of tobacco seed.

Plant Bed Covers	Seeding No.			Average
	1	2	3	
Plastic	64.2	71.5	68.0	67.9
Plastic plus nylon	78.9	72.8	83.1	78.3

Table 3. Effect of seeding density on the germination percentage of tobacco seed.

Seeding Densities	Seeding No.			Average
	1	2	3	
Low	72.7	74.3	75.6	74.2
High	70.7	70.4	75.4	72.2
Average	71.7	72.4	75.5	

Table 4. Effect of seed treatment, seeding density and plant bed cover on transplant parameters.

	Plant Weight (g)	Extended Length (cm)	Stem Length (cm)	Stem Diameter (mm)
Sized untreated	14.9	24.5	8.8	6.7
Sized treated	14.9	24.7	8.9	6.6
Unsized untreated	14.8	23.8	8.1	6.7
Unsized treated	15.5	24.9	9.2	6.7
Low seeding density	15.8	24.6	8.8	6.9
High seeding density	14.3	24.3	8.7	6.5
Plastic cover	16.0	25.1	9.1	6.9
Plastic plus nylon cover	14.0	23.8	8.4	6.5

Table 5. Effect of seeding time, seed treatment, seeding density and plant bed cover on the uniformity (coefficient of variability) of tobacco seedlings.

	Coefficient of variability (%)			
	Plant Weight	Extended Length	Stem Length	Stem Diameter
Seeding 1	77	37	61	29
Seeding 2	68	34	55	29
Seeding 3	69	33	56	27
Sized untreated	68	35	57	28
Sized treated	71	35	57	28
Unsized untreated	73	35	58	29
Unsized treated	70	34	55	28
Low seeding density	70	34	57	28
High seeding density	72	35	58	29
Plastic cover	69	34	57	28
Plastic plus nylon cover	70	35	56	28

Table 6. Average yield and coefficient of variability for various sizes of tobacco transplants.

		Group of Transplant				
		S	M	L	V2	V3
Average final yield (g/plant)		185	179	184	190	192
CV of final yield	(%)	22.4	23.7	24.9	20.0	22.5
CV of stem height at 1st week	(%)	31.5	31.8	34.1	52.8	44.5
" 2nd week	(%)	35.9	32.0	30.8	40.9	37.0
" 3rd week	(%)	30.1	26.3	26.3	31.8	29.1
" 4th week	(%)	25.3	23.2	21.6	25.3	24.4
" 5th week	(%)	17.9	16.0	13.2	14.9	15.4

S = small, M = medium, L = large

V2 = 50% small and 50% large, V3 = 1/3 small, 1/3 medium, 1/3 large

CV = coefficient of variability

Table 7. The effect of plant population of direct-seeded tobacco on total yield (leaf plus stalk).

Treatment	Effective Plants/Acre	Harvested Weight (lb/acre)	Cured Weight (lb/acre)	Ratio of Cured/Green Wt
1	7,260	17,881	2,340	.131
2	14,520	20,099	2,671	.133
3	29,040	29,489	3,532	.120
4	43,560	41,999	5,550	.132
5	87,120	56,056	6,701	.120
6	∿ 170,000	60,532	7,923	.131
7	> 500,000	82,299	10,427	.127

Table 8. Effect of harvest method on sugar and alkaloid percentages of plant components.

Harvest Method	Harvest	% Sugar			% Total Alkaloids		
		Lamina	Midrib	Stalk	Lamina	Midrib	Stalk
Whole Plant	1	6.7	9.6	7.7	2.82	0.76	0.47
	2	9.3	18.2	10.0	2.16	0.81	0.69
	3	14.0	12.1	8.9	2.17	0.84	0.51
	4	8.8	10.2	9.4	2.62	0.65	0.52
Barn Chopped	1	6.1	8.5	5.7	1.54	0.77	0.55
	2	14.2	11.0	6.9	1.99	0.73	0.29
	3	9.2	7.6	8.6	2.26	0.91	0.48
	4	9.2	9.7	8.1	2.20	1.20	0.58
Forage Chopped	1	5.3	4.4	5.7	1.32	0.64	0.23
	2	3.8	6.8	5.9	1.20	0.91	0.57
	3	4.8	6.3	6.0	1.01	0.37	0.45
	4	5.6	8.3	7.0	1.42	0.70	0.57
Control	1	1.7	6.0		1.16	0.56	
(leaves only)	2	6.3	11.3		3.23	1.16	
	3	4.1	7.7		4.34	1.43	
	4	7.5	3.7		4.26	1.26	

PROGRESS REPORT

ON

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January 1 - June 30, 1976

by

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PROGRESS REPORT -- MECHANIZATION OF CLOSE-GROWN TOBACCO -- January 1-June 30, 1976

I. INTRODUCTION

This 6-month report relates to continued research and development on Mechanization of Close-Grown Tobacco at N. C. State University under support by Carreras Rothmans, Ltd. Since initiation of the project in 1974, the research has emphasized mechanization of direct seeding, field production operations, harvesting and curing.

II. MECHANIZED PLANT PRODUCTION AND/OR DIRECT FIELD SEEDING

A. Background. Previous research of 1974 and 1975 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 protective covers.

In order to facilitate mechanization of successive operations such as seeding, covering, removal of cover, etc., a narrow-bed system is suggested whereby the tractor straddles the bed. Fumigation of adjacent beds (i.e. fumigation of parallel strips) in 1975 was not completely satisfactory for obtaining proper weed control due to occasional damage of the plastic cover by the rear wheels of the tractor which permitted some loss of the fumigant. It was also believed that some mixing of untreated with treated soil occurred during the subsequent tilrovating-seeding operation. This problem could likely be solved by a modified bed layout, fumigation of alternate strips or solid fumigation. The first approach would appear to be more economical if the problems can be resolved.

The prior field studies have been rather inconclusive in regards to the effects of seed sizing and pellet process; however, laboratory studies suggest advantages to sizing and better results for Asgro pelletted seed. In addition, there is reason to believe that seed pre-treatment, particularly in relation to breaking the light requirement, may improve field performance of G-28 seeds.

Specific objectives for the 1976 research were (1) to establish an improved bed layout system for methyl bromide fumigation and seeding (2) to improve the seeding device to permit simultaneous seeding of 18 to 20 rows on the pre-formed beds and (3) to study the effect of seed sizing and pre-treatment on uniformity of seedling development under various covers.

B. Materials and Methods. Approximately 1.5 acres were approved for this study at the Lower Coastal Plains Tobacco Research Station at Kinston, N. C. The land was located adjacent to the station's plant bed sites, having irrigation availability.

In planning for the study, the decision was made to emphasize mechanized transplant production at populations of up to 1.5 million/acre, since the approach is essentially the same as that for direct seeding for field production except for plant spacing. In this manner, a larger number of plants can be observed and results could be immediately applicable to improved plant production systems.

In order to achieve effective fumigation and subsequent seeding into a weed-free zone of the treated bed, a bed layout system was designed having the following characteristics.

Center-to-center tractor wheel spacing----------86"

Effective width fumigated-----------------------60"

Width of bed tilrovated-------------------------56"

Width of formed bed prior to seeding------------48"

Width of seeded zone----------------------------36"

This design permitted fumigation of adjacent beds with adequate clearance to avoid damage from tractor wheels, and allowed bed-forming and seeding into the 60" fumigated zone without mixing with untreated soil.

Equipment used was essentially the same as in 1975, but with modifications to achieve the above bed design and with a larger number of rows. Fumigation equipment was widened to fumigate an effective 60" strip and improved to obtain more accurate stability and depth control of the opening and closure discs. The seeder was further modified to provide 18 rows on the pre-formed bed, in four bands. Two bands were designed to provide 4 rows at 2" between-row and 1 1/2" within-row spacings. The other two bands provided 5 rows at 1 1/2" between-row and 1 1/2" within-row spacings. Thus, two densities of seeding could be tested. The bedformer and seeder attachment were further designed such that each band of seeds were firmed into a channel 1" deep and 7" wide, separated by 3" ridges. In this manner, the coverings were supported above the germinating seeds.

Speight G-28 tobacco seed procured in 1975 were separated into various size groups using precision sieves (354, 420, 473, 500, 532, and 563 micron respectively) and an ATM Sonic Sifter. Since seeds held on the 473 micron sieve constituted more than 50% of the seed population, these seed were selected as the "sized" lot. Sized and unsized lots were treated by soaking in water for 48 hours in the presence of light followed by drying to a constant weight under room conditions. Preliminary tests had established improved dark germination for seeds pre-treated in this manner, and that this property was retained under prolonged storage at room temperature.

Tobacco seed were coated by Asgro Seed Co. to provide four seed lots (treatments) for the field study:

Lot No.	Description	% Germination
1	G-28, sized, untreated	91
2	G-28, sized, treated	95
3	G-28, unsized, untreated	89
4	G-28, unsized, treated	93

The actual field work was initiated during November, 1975. The land was disced, turned and "shaped" to form a 40' wide raised bed between each irrigation line. According to the Station Superintendent, this should aid in drainage of water from the relatively flat land. Fertilizer was applied with a Gandy distributor at the rate of 2400 lb/acre of 12-6-6 to 4' bands between the wheels which outlined the beds (81" center-to-center). The fertilizer was mixed into the upper three inches of soil with a spring tooth harrow. Methyl bromide was injected into the soil at the rate of 300 lb/acre and covered with solid plastic (1.5 mil). All operations were conducted under favorable soil moisture and temperature conditions. Twenty-two beds of 220 ft. length and 12 beds of 180 ft. length were fumigated prior to inclement weather.

The beds remained covered during December and January. Preparations were made to begin seeding in early February. Plans were to conduct three seeding trials with 12 beds for the first trial, 10 for the second and 12 for the third. With the exception of seeding No. 2, sufficient beds were available for three replications of each of the four seed treatments with a seed treatment for each bed. Dates of the three seeding trials were No. 1 - Feb. 9-10; No. 2 - Feb. 16; and No. 3 - Feb. 26-27.

Procedures for each of the three seeding trials were essentially the same, with the exception of watering method. After removal of the solid plastic (which was destroyed during lifting), the beds were tilrovated and seeded. Granular DiSystem was applied by hand at the rate of 9 oz. of 15% granulated per 100 yd^2. Wheat straw mulch was hand applied at 3/4 bale per

100 yd^2. Next, sprinkler irrigation was applied to provide about 1/4"-3/8" of water during the late afternoon. For the third seeding, a portable water wagon with sprinkler boom provided more uniform watering. Two types of covers were applied to each bed: perforated plastic (3/8" holes on 3" centers) and perforated plastic + .5 oz/yd^2 nylon. Following covering, irrigation was provided only to prevent heat damage on unusually warm days when outside temperatures reached about 85°F.

Removal of covers for the three seedings was made on March 29, April 5, and April 15 respectively. At this stage plants were about 2" to 3" tall and pushing up against the covers. After removal of covers, the beds were topdressed with 16-0-0 at the rate of 750 lb/acre. Zineb (fungicide) was applied at approximately weekly intervals to control blue mold. Irrigation was applied as necessary to maintain proper growth. On one occasion, irrigation was used for frost prevention.

C. Sampling Procedures. In order to evaluate the effect of the various experimental factors, an extensive sampling study was conducted. Ten sampling sites were located for each bed, using statistical randomization for the first site and with equal spacing for remaining sites. At each sampling site, two samples of tobacco plants were collected from the two central bands which represented two plant densities. The collection area was 12" long x 6" wide.

Collection and measurement of plants was as follows. Plants were carefully cut at ground level, immediately placed in plastic bags, then stored temporarily in ice chests to minimize weight changes prior to taking measurements. Collected plants were taken to the laboratory and measurements made of individual plant weight, stem length, stem diameter and extended length. These data (for up to 20,000 plants) will be utilized to study the effect of various factors on plant variability, plant style, etc. Complete analyses of the data will require several months for card punching, computer analysis and statistical evaluation.

D. Results and Discussion. During the course of conducting the field study on mechanized plant production, various observations were made which appear important to assessing progress to date and to future studies.

1. Timeliness of Operations. This factor above all others appears to be of critical importance to success in mechanized plant production and to direct seeding. In order for seeding operations to be carried out systematically during February in eastern North Carolina, prior operations of land preparation, fertilization and fumigation are best accomplished during late

fall or early winter of the previous year. Fumigation and covering of beds with plastic when the soil moisture is at a favorable level makes it possible to later remove the cover and seed the beds even shortly following wet weather, snows, etc. Also, since suitable weather for seeding may exist for only a few days at a time, operations of removal of cover, tilrovate-seeding, mulching, watering, and recovering should preferably be accomplished within one day if possible and certainly require no more than two days.

2. Equipment Performance. Operations of land preparation, fertilizing and fumigating were carried out without any particular problems noted. Fumigation equipment operated quite well with effective placement and side covering of the plastic.

While removal of the plastic was by hand, it was noted that it would be practically impossible to remove it mechanically without damage because of the soil compaction. Furthermore, to avoid mixing untreated with treated soil, it was found desirable to slit the plastic near the bed center and pull the strips to the bed sides thereby moving untreated soil away from the bed.

The seeder worked quite well except that seeds dropped to the bed surface tended to bounce, roll, or be displaced due to wind. Without having small furrows in the bed surface, it was difficult to obtain precision spacing within or between rows. Nevertheless, the seed appeared to be fairly uniformly distributed within the bands. Occasional blockage of seed ports were noted during seeding; consequently, the seed drums were cleaned after each seed lot was planted. Firming of the coated seed into the upper 1/16" of soil was excellent, with all seed appearing to be compressed the same depth and to the same compaction.

Covering of beds following seeding was effectively accomplished without any major problems. It was noted that in both seeding and covering operations, a better job was obtained for level beds in contrast to those sloped to the side.

Since final operations of top dressing and spraying were carried out by straddling the beds, a high degree of precision and uniformity was obtained.

3. Weed Control. Excellent control of weeds was obtained this year with methyl bromide fumigation. Only minor contamination occurred during removal of plastic and subsequent seeding. It was noted that, in the several small areas where weeds did develop, holes in the plastic or high soil moisture

following fumigation caused loss of control.

4. Tobacco Seed Germination and Early Growth. In general the results in 1976 were quite good and far superior to previous tests. As postulated in previous years, it now appears confirmed that adequate soil moisture must be available to readily break down the coating material for high germination percentages. In all of the 1976 seeding trials, the beds were watered soon after seeding and before covering to provide breakdown of the coating and to supply enough water to sustain growth until removal of the covers (up to 8 weeks).

While variability was observed at various locations in the field and on each bed, many locations showed very high germination percentages (estimated up to 90%). Actual results of the sampling study will be reported later, which will deal with effects due to type of cover, seed treatment, density of seeding, etc.

5. Factors Contributing to Variable Plant Growth. Apart from basic differences existing among seeds (size, density, vigor, etc.), several factors were noted which significantly affected the variability of seedling development. The largest single effect appeared due to variations in soil moisture, which likely also influenced soil temperature. At the time of seeding, soil moisture variations were observed which continued throughout the season. It was noted that low spots of the field which had poor drainage allowed accumulation of water beneath the fumigated beds. The critical importance of uniform drainage of water from the field during the period between fumigation and seeding was evident. Furthermore, overhead irrigation was found to contribute to additional soil moisture variability, either by the fact that the system does not provide uniform application and by the secondary effect due to wind. This observation led to the test of a portable watering system for greater uniformity in applying water immediately following seeding and during latter stages of growth.

Other factors which are considered to have influenced variability include (1) seed displacement due to impact of water droplets from sprinkler irrigaton, (2) differences in nutrient availability due to differential leaching at various locations as a result of non-uniform watering, (3) variability in application of wheat straw mulch (this operation was greatly influenced by wind and by person applying the mulch), (4) height of cover over germinating seed or young seedling, and (5) variability in seed placement due to slope of beds, wind, and lack of precision in seeding.

III. SUPPLEMENTARY TESTS ON DIRECT FIELD SEEDING

A. Mechanical Application of a Fiber Mulch. It has been found in forest tree nurseries that application of a fiber mulch applied uniformly over new seedbeds enhances moisture retention minimizes soil erosion, and generally improves seed germination. Since hand application of wheat straw actually contributed to increased variability, a test was made in late March to observe the potential of a hydro-mulch procedure whereby a wood fiber is sprayed onto the bed following seeding.

Two beds were treated with methyl bromide and seeded with coated seed from Lot 1. Approximately 1/8" of fiber mulch was applied to one of the two beds, then both beds were watered to field capacity (about 1/2" of water). Three types of coverings (nylon, perforated plastic, and nylon + perforated plastic) were applied to each bed.

Results showed dramatic improvements in seed germination and uniformity where the fiber mulch was used. This was particularly evident for the portion of beds covered with nylon, where the soil could dry out much faster. In this case, the fiber mulch apparently reduced drying and enhanced germination. But even for beds covered with plastic, there was a visible improvement noted for the mulched bed. In addition to aiding in moisture retention, it is possible that the fiber mulch helps to maintain proper seed-soil contact by minimizing seed displacement during irrigation immediately following seeding. Also, the procedure may provide a more uniform micro-environment for the seed.

B. Effect of Plant Population on Yield. Following the collection of samples from the major field study, a small study was planned to observe the effect of plant population on yield. Seven plant populations, ranging from about 6000 to about 1/2 million or more (unthinned) plants/acre, were established by thinning randomly selected plots of about 20' length. Sixty-three plots provided three replications of each plant population for each of three harvest dates. Following thinning of the plots, the beds were top-dressed with 15-0-14 to provide 50 lbs. of N/acre. Irrigation was provided as necessary to maintain normal growth.

Three harvests were made during June. Plants were handcut with machetta, tied to sticks, and cured in conventional flue curing barns. After the summer harvest season, yield data will be collected. Because of the field variability in soil moisture and high organic content of the soil, the quality of the leaf appears poor and results will likely be variable. The results may provide, however, further indication of yield potentials, particularly from the unthinned plots. It was noted that thinning appeared to reduce the plant growth rate, with greatest effects noted for the plots most heavily thinned. Root damage to remaining plants within beds very likely results when some plants are pulled by hand.

IV. <u>FIELD PRODUCTION OF CLOSE-GROWN TOBACCO</u>

A. <u>Background</u>. During 1974 and 1975, a cultural management program was developed for the production of close-grown tobacco. This program, from land preparation to harvest, emphasized mechanized operations. In 1975, the crop looked excellent until July and the occurrence of about 16 inches of rain. Leaf quality suffered greatly and yields were reduced. Also in 1975, a modified forage harvester was tested for use in harvesting the entire plant with CGT, with handling and curing in a chopped form. Extensive bruising caused problems in curing to an acceptable quality.

Plans were developed to produce in 1976 approximately 3.0 acres of CGT at the Oxford Tobacco Research Station using a cultural management program similar to that outlined for 1975. Objectives were (1) to produce a crop under mechanized operations of fertilization, bedforming, transplanting, cultivation, spraying, and harvesting with emphasis on maximizing yield and usability of the cured product, and (2) to produce experimental materials for evaluation by Carreras Rothmans, Ltd. and NCI.

B. Materials and Methods. Experimental procedures have followed basically the plan as outlined in the 1975 Annual Report, but with slight modifications.

A field plot having about 3.5 acres total land was assigned for the study at the Oxford Tobacco Research Station.

Land preparation consisted of discing, turning, re-discing, and harrowing during the months of March and April.

Pre-plant chemicals were applied as follows:

(1) for weed control - Paarlan at recommended rate of 1 qt/acre.

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

(3) for insects (flea beatles and aphids) - DiSyston at 4.0 lb/acre.

It was hoped that multi-purpose fumigant could be applied, but these plans did not materalize due to lack of suitable equipment for bed fumigation. Following spray application of chemicals, the field was again disced.

Pre-bedding with listers was performed in early May, using 84" center-to-center bed spacing. The layout provided for an irrigation lane between each 5 beds.

Pre-plant fertilization was applied mechanically to the beds using a Gandy distributor. Rate of fertilizer application was 1000 lb/acre of 8-16-24 to provide about 80 lb/acre of N. Beds were tilrovated to a four-inch depth following fertilizing.

Transplanting was carried out during the period of May 11 to June 2 to provide staggered plantings and extended harvest. The same transplanter was used as in 1975 to provide 4 rows/bed with 16" spacing between rows and 10" spacing within rows (39,000/acre effective plant population).

At about two and four weeks after transplanting, the tobacco was cultivated and topdressed to bring total N to 140-150 lbs/acre. Post-plant fertilizer consisted of 15-0-14 for the first topdressing and 16-0-0 for the second topdressing at roughly equal amounts per application.

Sucker control chemicals used consisted of Off-Shoot T applied in the early flowering stage and MH-30 applied following topping. Recommended rates were applied but with an increased number of nozzles to obtain effective coverage of the close-spaced rows. Plants were topped by hand to leave 15-17 leaves/plant.

C. Observations. Up to the time of beginning harvesting, the field production of CGT looked better than any of the previous years. Weed control was excellent with only an occasional weed which survived. Sucker control, in general, was good; however, an occasional side row appeared to have been inadequately sprayed. This could have resulted from a steering error or a difference in width of the irrigation lane.

Leaf development appeared somewhat better than in previous years. While leaf deterioration occurred at the bottom of the plant with loss of 4 to 6 leaves, the upper leaves appeared to fill out and mature to form almost normal sized leaves. Yields of 6000 lbs/acre or higher are expected for the better portions of field.

V. MECHANIZED HARVEST AND PROCESSING

A. Background. In 1975, tests were initiated on mechanized harvest and handling of CGT using a modified forage harvester with forage wagon. While measures were taken to reduce bruising (reduced cutterhead rpm, reduced number of blades, less vigorous feed-rolls), cured leaf quality was considered to be reduced appreciably due to continued excess bruising.

Plans for 1976 were made to continue studies on the "modified forage harvester approach" with objectives of (1) further reducing bruising during the harvest operation, and (2) comparing the curability of forage machine chopped, stationary cutter chopped, and whole plant tobacco from the CGT field study. By appraising the extent of physical and chemical damage due to the forage harvester approach, it may be possible to measure progress in machine development or of harvest technique in subsequent tests.

B. Materials and Methods. The same basic harvesting equipment procured in 1975 will be used for the 1976 harvest trials. Pre-harvest changes to the forage harvester have included (1) decreasing cutterhead rpm from 715 to 322 rpm (this increases cut size from 1.75" to 3.9") and (2) incorporating a fan which provides air assist in moving the chopped material to the wagon. Preliminary tests indicated the necessity of the fan assist to provide sufficient momentum to the chopped material to move back to the wagon.

Harvest and curing tests are currently underway and will continue over a period of about six weeks. The procedure for harvest is as follows: At least one day per week, a portion of the field tobacco will be harvested, trying to achieve near optimal leaf development and maturity at harvest. One lot of tobacco will be machine harvested and the chopped material loaded directly from the wagon into the curing modules. A second lot will be hand harvested with machettas and the plants fed through the stationary cutter to provide 3" x 5" strips or segments. These will be conveyed into the same type curing modules. A third lot will be harvested as whole plant and bulk cured in racks. Curing procedures will follow the typical schedules for flue-cured tobacco. Following curing, the dried material will be packaged in export type shipping cartons for storage.

Observations during harvest and curing will include machine performance, apparent bruising, harvest rate, curing conditions, and subjective evaluation of curability.

Cured materials will be submitted to NCI for biological tests, with select samples or lots retained for chemical analyses by NCSU or evaluation by Carreras Rothmans, Ltd.