1979 ANNUAL REPORT

ON

MECHANIZATION OF CLOSE-GROWN TOBACCO

by

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I. INTRODUCTION

This report describes the sixth 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 close-grown (high plant population) tobaccos.

II. MECHANIZED TRANSPLANT PRODUCTION

A. Background. Major objectives of this research are to improve efficiency of transplant production and to increase transplant quality and uniformity. A transplant production system is under development involving mechanized operations of land preparation, bed forming, fertilization, fumigation, seeding, mulching, covering, and ultimately, lifting of the plants. Field tests have been conducted to evaluate the effect of various parameters such as weed control method, seed size and pre-treatment, seed-coating method, seeding density, mulch type and density, and type of seed bed cover on uniformity of seedling development. Uniformity improvements appear to be associated principally with operations or factors which establish a more uniform microenvironment for seed germination and plant growth, such as mechanized bed forming, seeding, watering, etc. Non-uniformity appears to result largely from gradual development of a non-uniform microenvironment beneath the covers, due to non-uniform water entry, irregular drying, variations in cover height, and other factors.

Because of previous results which indicated that type of cover greatly affected temperature, moisture retention and uniformity of soil moisture beneath the cover, it was of interest to examine further the effect of type of cover. Perforated plastic is a "warm" cover, allowing some water penetration and is widely used by growers. Polycoat is a solid plastic with spun-bonded nylon overlay which provides lower light transmission but higher moisture retention than perforated plastic. Nylon is a very porous, "cool", cover which permits uniform water entry but more rapid moisture loss than perforated plastic. It was, furthermore, of interest to examine the effect of the presence of a surface mulch vs. no mulch on plant development. While a mulch should serve to stablize the soil and retard soil moisture evaporation, it does pose a physical barrier to the tiny emerging seedling. Under laboratory conditions, dark-treated seed (i.e., seed soaked under darkness for approximately 1 week or longer) appeared to germinate with improved synchrony when exposed to light. It was of interest, therefore, to include pregerminated light vs. dark treated seed in comparison with normal seed. Other factors of interest included bed surface and height of cover.

Studies were continued in 1979 at the Lower Coastal Plains Tobacco Research Station on development of a mechanized system for producing transplants. As in previous years, the experimental plan was designed to include the best combination of factors (which, on the basis of previous results, produces the most uniform transplants) in comparison with new factors under study. Specific objectives are (1) to study the effect of type of cover, mulch treatment, and seed treatment on uniformity of seedling development (Experiment I), (2) to study the effect of method of bed forming, cover type and height of cover on uniformity of seedling development (Experiment II) and (3) to obtain further knowledge regarding the effect of microenvironment on seed germination and early growth of seedlings.

B. Materials and Methods. The experimental plan for Experiment I consisted of a split-split plot design with complete randomization within each plot. Factors included three covers (perforated plastic, polycoat, and nylon), two mulch treatments (Turfiber mulch vs. no mulch), and three seed treatments (normal, light treated, and dark treated). Four blocks (replications) of 6 beds each were provided, with each bed approximately 200 ft. in length. The bed layout system was the same as described in the previous studies.

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

Effective width fumigated.......................60"

Width of tilrovated bed.........................56"

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

Width of seeded zone....................approx. 42"

Irrigation lanes were located between the 2nd and 3rd, 7th and 8th and 11th and 12th beds.

Because of adverse weather during late fall of 1978, beds were fertilized and fumigated during March of 1979. Fertilizer was applied to a 5-ft width at the rate of 2400 lb of 12-6-6 per acre. Methyl bromide was injected into the soil at the rate of 350 lb/acre and the beds covered simultaneously with 2.0 mil solid plastic. These operations were completed March 20, 1979.

Beds for Experiment I were seeded with variety G-28 seed on March 27-30 as follows. After removal of the solid plastic, beds were tilrovated and bedformed using equipment described in a previous report, with channels formed to aid in keeping the cover from adhering to the soil. A Finn hydroseeder was used to seed the beds to an estimated 47 seed/ft^2, with Turfiber mulch applied at 1400 lb/acre for the mulch-treated beds. Beds were then watered using a portable water wagon with pressure boom to obtain 0.5-inch H_2O. Beds were covered with 1.5 mil perforated polyethylene (3/8" holes on 3" centers), nylon (.4 oz/yd^2), and polycoat (.4 oz nylon with .5 mil polyethylene). From seeding until removal of covers (April 25-May 1), irrigation was applied during periods when the soil appeared to be drying excessively beneath the nylon covers.

The experimental plan for Experiment II consisted of a split-split plot design with complete randomization within each plot. Factors included three methods of bed forming (flat, with channels, and culti-packed), two covers (perforated plastic and nylon) and cover height (low and raised). The cultipacked bedforming produced a rippled surface effect with shallow parallen channels 2.25 inches apart. The "low" cover height signifies normal placement wherein the cover is placed directly on the bed, whereas the raised cover involves placement of shaped rods at about 24-inch spacing which suspends the covers about 3 to 5 inches above the beds. Three blocks of three beds each were provided, with each bed approximately 190 ft long.

Seeding operations for Experiment II were conducted between April 12-19. Following removal of solid plastic, the beds were tilrovated and bed-formed and/or cultipacked. All beds were hydroseeded (Speight G-28, normal seed) using a Finn hydroseeder and 1400 lb/acre of Turfiber mulch. Estimated seeding density was 47 seed/ft^2. After watering and insertion of support rods, the beds were covered mechanically with perforated plastic and nylon. Covers remained on beds for 4 to 6 weeks, during which time irrigation was applied as required.

Samples of seedlings were collected for measurement of stem diameter and extended length (for uniformity studies) when most plants were of transplant size (may 21-25 for Experiment I and mid-June for Experiment II). Five sampling sites were selected per experimental plot. The collection area for each sample was 7" x 12". Plants were cut at ground level, placed into plastic bags, and stored in ice chests until measurements were made. In addition to stem diameter and extended length, plants/sample area were recorded.

C. Results and Discussion. Statistical analyses of the data have not been completed; however, observations were recorded during the experiments which relate to the effect of various factors on growth and uniformity. For Experiment I, perforated plastic appeared to cause increased variability, particularly associated with non-uniform water entry. Nylon and polycoat covers appeared to produce more uniform conditions; although, plant growth rate was reduced. Turfiber mulch appeared advantageous in reducing seed displacement after seeding, stabilizing the soil and reducing moisture loss. Late season observations, however, showed that plants appeared to be less green and smaller than plants from unmulched beds. Seed treatments appeared to cause slightly improved uniformity; however, the data must be evaluated to accurately assess the effect. Hydroseeding was found to be a very satisfactory method of seeding with excellent distribution of seed obtained.

For Experiment II, it was of interest to note that raised covers appeared to produce more uniform plants in most cases. Sagging of covers and adherence of covers to the soil with the low covers can be a major problem as noted in previous studies. Cultipacked beds having raised nylon covers produced the most uniform plants; whereas flat beds having low perforated plastic covers showed considerable plant damage and non-uniformity. Cultipacked beds provided a surface which appeared to be less conducive to erosion and washing by rain; hence, less seed displacement due to rains is expected for the case of nylon covers.

III. EFFECTS OF TRANSPLANT VARIABILITY

A. Background. Studies were initiated in 1977 at the Lower Coastal Plain Tobacco Research Station to examine the effect of transplant variability on final yield and quality. The major importance of this work is to enable selection of a range of transplant sizes from the mechanized production system which is most suitable for farmer application. In addition, data is provided which will be important in specifying the degree of transplant uniformity necessary to permit single-pass harvesting of plant beds (without sorting).

Previous studies in 1977 and 1978 gave the following results: (1) variability of final stem height and final yield were not affected by initial transplant variability, (2) under adverse weather conditions following transplanting, larger and stockier plants appeared to survive better and gave higher yields, and (3) no apparent trends have been noted between initial transplant size and final quality, based on grade analyses. The study was continued in 1979 to provide a third-year replication of the study.

B. Materials and Methods. Ten groups of seedlings of different sizes were selected according to the same plan as used in 1977, except for slight changes in the ranges of plant parameters. Seedlings in groups 1-9 were selected on the basis of extended length and stem diameter, with each group having a relatively narrow range of each plant parameter. Group 10 was obtained by mixing an equal number of plants from each of the nine selected groups. Rnages for the two parameters for each group are shown in Table 1.

The ten groups of transplants were transplanted in a randomized block layout with 22 plants per group (row). The main block was replicated four times. All groups were transplanted on 48-inch rows with a conventional 2-row transplanter. Cultural practices were the same for all size groups. Plants were grown under normal culture, were hand topped, and sprayed with sucker control chemicals. Tobacco was harvested at approximately 2-week intervals to obtain bottom, middle and top one-third of the leaves. Leaves from each plant were tagged and cured conventionally on sticks. Cured leaf weights and government grades were established for each cured sample.

C. Results and Discussion. Table 1 shows the range of plant parameters and cured weight data for each treatment. The data, averaged over replications, shows that initial plant size had very little effect on yield/plant or on its coefficient of variability. In fact, it is surprising to note the very low CV's which average only 10.8%. Plant size did influence the percentage of surviving plants. The smallest plants (17-23 cm extended length, 4.5-5.7 mm stem diameter) were observed to suffer most from transplant shock with only 77.5% plant stand. This could produce an actual reduction in yield of up to 600 kg/ha. Yield reductions appear to be evident for groups 1 and 2. Yields appear to be slightly higher for the larger plants of groups 7, 8 and 9.

IV. DIRECT FIELD SEEDING

A. Background. Prior work in 1978 was conducted to observe overall effects of management and curing on characteristics of Oriental tobacco, direct seeded over a wide range of plant populations. Seeding techniques utilized a multi-row seeder for coated tobacco seeds, and nylon covers. The work was continued in 1979 to further evaluate direct seeding and production of Oriental tobacco. Specific objectives were (1) conduct research on further development of a mechanized system for producing close-grown Oriental tobacco, (2) test hydroseeding as a means for establishing desired plant populations, and (3) observe the overall effects of plant culture and curing on yield and leaf characteristics. Basic premises of this work are the concepts of direct seeding and once-over mechanical harvesting. It is envisioned that the cured product might be utilized as a blend component of reconsituted sheet (using perhaps leaf and stalk) or leaf might be used in the traditional manner.

B. Materials and Methods. Procedures for land preparation and seeding were similar to those described for the mechanized transplant production studies. Land preparation, fertilization and fumigation were completed April 24-25 and beds were seeded on May 3, 1979. Fertilizer (8-8-24) was applied at approximately 1000 lb/acre to 40 beds of 86-ft length; then the beds were fumigated with methyl bromide injected at 335 lb/acre and covered with 2.0 mil solid plastic. After removal of covers, the beds were surfaced with a cultipacker, to produce parallel channels approximately 1-inch deep and 2.25-inches wide. Beds were hydroseeded using the Finn hydroseeder at 1800 lb/acre mulch rate. Four seed populations were introduced for Oriental (Smyrna) tobacco: 87,000, 174,000, 232,000 and 348,000 seed/acre. For observation, a flue-cured variety (G-28) was introduced at the 87,000 seed/acre density. Since the beds occupied 4/7 of the total land area, actual populations were about 60% of the above values. Beds were watered and covered with nylon and polycoat, with irrigation applied as required during the next two-week germination period. The experimental plan consisted of a split-plot design with 2 covers, 5 seeding treatments within each cover, and 3 blocks (replications).

Following removal of covers, the beds were topdressed with 15-0-14 at the rate of about 250 lb/acre. Since the plants were randomly spaced on the beds, mechanical cultivation could not be used. The few weeds which grew were hand pulled; however, middles between beds were cultivated mechanically and sprayed with Enide for weed control. In early July, a second topdressing was applied at 10 lb N/acre rate. Only July 13, plants were sprayed with Off-Shoot T with the objective of chemically topping the plants. This however did not prove to be satisfactory.

Tobacco was harvested early (July 23) due to a heavy storm which caused lodging of plants. Many plants were blown over due to flower heads, which developed after application of Off-Shoot T. Plants were cut with machetes, packed into bulk racks, and cured in a whole-plant form. Only enough tobacco was harvested from each bed (treatment plot) to fill one rack. Curing followed a typical flue-curing schedule with stem drying temperatures of about 170^{o}F. Leaf chemistry and smoke analyses were conducted by a cooperating tobacco company.

C. Results and Discussion. Qualitatively, the tobacco after curing appeared to be of much lower quality than normal Oriental leaf. In an attempt to yellow the somewhat immature leaf, the yellowing period was extended and considerable browning occurred during the early leaf drying phase.

Table 2 illustrates the effect of plant population on leaf chemistry and overall yield of the Oriental tobacco. Relative to typical Oriental tobacco, the close grown, whole plant harvested material had lower total alkaloids and sugars and higher ash content. These differences may be due to the early harvest of the immature plants and to prolonged yellowing during the cure.

On the basis of harvested areas and cured weight data, yields were calculated to range between about 2000 and 3500 lb/acre with higher yields associated with the higher plant population.

Tobacco leaf samples from the low population (87,000 plants/acre) were combined across replications to form a sufficient quantity for sheet production. Material from sheet production was used for cigarette production both at the 100 percent level and in a blended cigarette as a replacement for the Oriental component. Taste evaluation of cigarettes indicated that:

1. 100 percent sheet cigarettes had similar characteristics to sheet from other base components, but had no Oriental character.

2. The blended cigarettes with the sheet were inferior to those containing Oriental leaf and were easily distinguishable by smoking panels.

Other observations were made during the course of the experiment that may be important to further studies. Under conditions of heavy rains during germination and early growth under nylon or polycoat, the covers may be loosened and may stick to the soil, causing problems in germination or affecting growth. All indications to date suggest that definite advantages could be obtained by elevating covers at least two inches to avoid the cover contacting the soil or germinating seeds. During this study, plant stands were good in places, to poor or spotty in other places depending on cover effect. As in the previous studies, it was apparent that careful control of irrigation for nylon beds is essential. Plants were noted to grow rapidly after germination, with number of days between seeding and flowering of only 75-80 days. Because of tendency of plants to lodge under heavy wind or rain, there may be an advantage to early topping prior to flowering. Earlier and lower topping could likely increase alkaloid levels toward those of typical Oriental leaf.

Another observation relating to leaf quality was that the tobacco seemed to be quite susceptible to weather fleck, with considerable damage occurring to bottom leaves prior to harvest. This effect could be accentuated due to rapid growth occurring under moist, humid conditions. Earlier seeding and growth might be advantageous in reducing this problem.

V. STUDY OF SYSTEM LAYOUT AND CERTAIN FIELD VARIABLES ON PRODUCTION OF CLOSE-GROWN TOBACCO

A. Background. During 1977, a study was initiated at the Oxford Tobacco Research Station to examine the effects of various bed layouts, in combination with a range of topping heights and plant spacing on yield, lower leaf loss and leaf quality. This work is of particular importance to the selection of the most suitable layout, since various equipment items must be selected or developed for the specific layout. To fully evaluate the above factors, a 3-year study was planned.

B. Materials and Methods. A field experiment described in detail in the 1977 report was continued for the third year to study four bed layouts, two within-row spacings (9" and 18") and four topping levels (18", 24", 30", and 36"). The four layouts were as follows:

(1) 4-row on bed: raised bed, four to six inches high, 86" bed spacing, 16" between rows.

(2) 3-row on bed: same as (1) but 24" between rows.

(3) 3-row flat: same as (2) but planted flat.

(4) 2-row flat: center-to-center spacing of 48" between 2-row pairs, 12" between rows.

Plant populations for the different treatments were as follows:

Layout	Spacing	Actual Plants/Acre
4-row	9-inch	32,400
	18-inch	16,200
3-row	9-inch	24,312
	18-inch	12,156
2-row	9-inch	29,040
	18-inch	14,520

Field plots of each treatment combination were approximately 30 ft long to provide 60-160 plants/plot. Four replications were made to provide 128 field plots. Following land preparation, preplant chemicals (MoCap, Di-Syston and Tillam) were incorporated for insect and weed control. Fertilizer was also incorporated at 800 lb/acre of 8-8-24. Beds were transplanted on May 22, 1979.

Two cultivations were made at approximately two and four weeks after transplanting with total N of approximately 150 lb/acre established with two topdressing applications.

Plots were hand topped and Off-Shoot T and Royal MH-30 applied for sucker control.

Harvest of plots were made when tobacco maturity and ripeness were adjudged most suitable for the entire plant. Tobacco was bulk cured in a whole plant form in racks under typical flue-curing management.

C. Results and Discussion. Evaluations to be made include yield and quality; % yield of stalk, lamina and midrib for bottom, middle and top stalk positions; chemical analyses for various plant components; and tar and PMI determinations on lamina. At this time only data on yield has been completed. Table 3 shows the effect of various layouts, spacings and topping heights on yield/acre. Again as in previous year, yield increased with topping height with up to 1800 lb/acre increase as topping height increased from 18" to 36". For each layout, closer spacing increased yield significantly. Yield differences due to layout do not appear to be significant, with a reversal of trends suggested by earlier data. From the standpoint of ease of mechanization, the 2-row layout offers distinct advantages while indicating high yield rather consistently over years.

VI. RAPID DRYING OF CLOSE-GROWN TOBACCO

A. Background. Smoke evaluations of certain close-grown tobaccos either harvested prior to maturity or dried rapidly indicate that modified drying procedures might be utilized for close-grown tobaccos produced specifically for reconstituted sheet. Rapid drying could also reduce curing time, energy, and equipment costs. For these reasons a test was conducted to examine the comparative chemical and smoke characteristics of normally cured vs rapidly cured tobacco.

B. Materials and Methods. Three varieties of tobacco (Speight G-28, G-28 Mammoth and pale yellow) were planted using a randomized complete block design with seven blocks. The 2-row layout described previously was utilized and the same cultural practices were followed except the tobacco was topped high at about 40 to 44 inches. Irrigation was applied as required to produce a normal crop.

As the tobacco neared maturity, heavy rains caused some root damage, which reduced yield considerably, particularly for about half of the field.

Tobacco was harvested on two dates, July 30 and August 14. At each harvest, tobacco was cut by machete and intact plants packed into bulk racks. Two small bulk barns were utilized for curing. Approximately half the tobacco was normally cured, following the typical 2-3 day yellowing schedule and then drying at elevated temperatures. For rapid drying, the temperature was advanced immediately on starting the cure to 115^{o}F and, after wilting the tobacco for 12-15 hours, the temperature was advanced at 5^{o}/hr to 160^{o}F.

C. Results and Discussion. Tobacco following rapid curing was noted to have relatively little brown discoloration, rather had a clean, pure color indicating good color fixation. For evaluation purposes, tobacco samples have been submitted to a cooperating company for preparation of reconstituted sheet and smoking comparisons. In addition, samples are being analyzed by the tobacco chemistry laboratory at N. C. State University.

Yield estimates for the 1979 study ranged from about 3000 to 3500 lb/acre, which are considerably below normal. This work will be continued in 1980.

VII. RESEARCH PLANNED FOR 1980

A. Mechanized Transplant Production. This work will be continued with the following objectives:

1. To demonstrate, under larger field plot tests, the best combination of treatments known to date in the production of more uniform transplants.

2. To study the effects of fluid drill and hydroseeding techniques, raised vs. unraised covers, and type of cover on plant growth and uniformity.

3. To give preliminary consideration to the next phase of mechanized transplant production, i.e., lifting of plants for labor reduction in pulling plants for transplanting.

The above research will be conducted at the Lower Coastal Plain Tobacco Research Station on the same field site as used previously. Sampling of plants will be performed when plants reach transplant size, and appropriate plant parameters measured and evaluated for the various treatments.

B. Effects of Transplant Variability. In contrast to the previous work, studies will be directed towards determining the effect of various operations at time of plant lifting (pulling) on growth, yield and quality. It is of interest to examine such factors as clipping of plants and undercutting and their effects, separately or in combination. It is also of interest to begin a comparison of plant performance between conventional and mechanized plant production systems.

C. Direct Field Seeding. Late season trials of direct field seeding will be continued with the objectives of (1) improving the quality of close-grown Oriental tobacco, (2) adopting raised covers in conjunction with improved bed surfacing procedures to improve germination and early growth, (3) to study the comparative performance of several varieties. Tobaccos will be grown on a 1-acre site to a harvestable stage, then bulk cured in a whole-plant form. Various evaluations will be made including yield, leaf chemistry and suitability for use in cigarettes, directly or after reconstituting into sheet.

D. Rapid Drying of Close-Grown Tobacco. Studies will be continued to compare the chemical, physical and other characteristics of normally cured and rapidly dried close-grown tobacco. Approximately one acre of Speight G-28 tobacco will be grown at the Oxford Tobacco Research Station, using a 2-row layout and culture described previously for the 1979 work. Harvested tobacco will be cured in whole-plant form by normal and accelerated curing schedules, with data recorded to enable determination of effect of curing procedure on cured weight yield, energy consumption per unit cured weight, and chemical changes associated with curing. Cured products will be submitted to a cooperating company for pertinent evaluations.

Table 1. Average values of cured weight/plant, coefficient of variability (CV), plant stand, and yield for various sizes of transplants.

Group No.	Plant Size Before Transplanting: Extended Length Range (cm)	Plant Size Before Transplanting: Stem Diameter Range (cm)	Cured Wt/Plant (g)	Cured Wt CV	Plant Stand %	Yield* kg/ha
1	17-23	4.5-5.7	163.07	8.85	77.5	1874
2	17-23	5.8-7.1	172.72	7.98	85.0	2177
3	17-23	7.2-8.6	163.16	13.89	97.5	2360
4	24-30	5.0-6.3	164.30	2.97	93.8	2285
5	24-30	6.4-7.8	158.18	12.46	96.3	2258
6	24-30	7.9-9.4	178.20	6.54	86.3	2280
7	31-37	5.5-7.0	165.09	13.66	96.3	2356
8	31-37	7.0-8.5	166.57	8.61	96.3	2377
9	31-37	8.5-10.0	163.98	3.70	97.5	2371
10	17-37	4.5-10.0	169.98	10.78	92.5	2337

*Weight corrected for % stand.

Table 2. Effect of plant population on certain chemical analyses and yield of Oriental tobacco[1].

	PLANT POPULATION				
	87,000	174,000	232,000	384,000	Typical Oriental[2]
Total Alkaloids (%)	.53	0.44	0.43	0.40	1.0
Total Nitrogen (%)	2.0	1.9	1.8	1.8	2.6
Total Volatile Bases (%)	0.18	0.17	0.16	0.13	0.2
Petroleum Ether Extrac. (%)	4.0	3.8	4.2	4.3	-
Sugars (%)	<2.0	<2.0	<2.0	<2.0	12.4
Ash (%)	26.4	23.6	23.4	25.4	14.8
Yield (lb/acre)	2092	2764	3216	3378	
% Stalk	59.45	-	-	60.24	
% Leaf	33.0	-	-	32.45	
% Top	7.55	-	-	7.30	

[1] Chemical analyses of leaf only. Chemical values shown are averages over six replications.

[2] Harlan, W. R. and J. M. Moseley, 1955. Tobacco Encycl. Chem. Tech. 14:242-61.

Table 3. The effects of field layout, plant spacing, and topping height on the final yield of close-grown tobacco.[1/]

Layout	Plant Spacing (in.)	Topping Height (in.)	Yield (lbs/acre) R1	R2	R3	R4	Mean	Mean	Mean
4-row on bed	9	18	3234	2984	3228	3215	3165	4308	4118
	9	24	4341	3316	5392	4678	4432		
	9	30	5401	4283	4542	4293	4530		
	9	36	6368	4292	4063	5300	5006		
	18	18	2939	3120	3013	3040	3028	3928	
	18	24	3383	3718	3857	3985	3736		
	18	30	5205	3996	4542	4269	4503		
	18	36	5408	4044	4063	4264	4445		
3-row on bed	9	18	3692	3435	4867	3367	3840	4605	4005
	9	24	4907	3535	5297	3827	4392		
	9	30	5158	4788	5154	4718	4955		
	9	36	4782	5528	5983	4634	5232		
	18	18	2423	2413	3005	2587	2607	3405	
	18	24	3128	3137	3270	3624	3290		
	18	30	3984	3727	3744	3669	3781		
	18	36	3746	3985	4342	3691	3941		
3-row on flat	9	18	4316	4198	4003	4111	4157	5136	4501
	9	24	4677	4905	5204	5986	5193		
	9	30	6113	5580	5341	4763	5449		
	9	36	6218	4584	5329	6854	5746		
	18	18	2912	2959	3366	3173	3103	3866	
	18	24	3496	3349	4077	3459	3595		
	18	30	4323	4237	3767	4366	4173		
	18	36	4764	4474	4235	4898	4593		
2-row on flat	9	18	5540	3867	3565	3578	4138	4896	4430
	9	24	5032	3914	4496	4489	4483		
	9	30	5090	5842	5367	5793	5523		
	9	36	5303	4546	5891	6012	5438		
	18	18	2902	3473	2705	3669	3188	3964	
	18	24	3385	3639	3490	3578	3523		
	18	30	4590	4607	4097	4863	4539		
	18	36	4908	4427	4102	4989	4607		

[1/] Based on actual land use exclusive of irrigation lanes.