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Flue-cured Tobacco Trials in the Dry Zone Ricelands of Ceylon

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(Received April, 1968)

INTRODUCTION

FLUE-CURED cigarette tobacco is a crop which is very sensitive to the factors affecting growth and productivity. Apart from the soil and climatic conditions, the variety, nutrition and cultural treatments have an important influence not only on the yield but also on the quality of the crop which is of supreme importance in manufacture.

It had been found from experiments conducted at the Agricultural Station, Anuradhapura and subsequent trials at Hingurakgoda and Polonnaruwa farms in the early 1950s (1) that flue-cured tobacco could be cultivated successfully as a *Yala* crop under controlled irrigation in the well drained ricelands of the Dry Zone. These lands are fast becoming important extension areas because of the need for increased production of flue-cured tobacco. Therefore, with a view of improving the yield and quality of these tobacco, experiments have been conducted by the Department of Agriculture during the past years on the varietal, nutritional and cultural aspects of the crop.

For nearly three decades since flue-cured tobacco cultivation started in Ceylon, the variety Harrison's Special (H.S.) had dominated the industry (2).

From the year 1958 introductions of commercial varieties from the major flue-cured tobacco producing countries of the world were made and after acclimatisation, their performances were studied in observational plots and replicated trials against the local H. S. variety.

The following varieties were tested :—

Source	Variety
U.S.A.	.. Golden Wilt, 402, Dixie Bright, Golden Harvest, White Gold, Golden Cure, Coker 187, Hicks Broad-leaf, Virginia Gold, Vesta 30, Vamorr 50, D. B. 102, Coker 139, N. C. 95, Coker 140.

Source	Variety
Canada	Delcrest.
S. Rhodesia	Kutsaga 51, Rhomos 7, Hicks, Canadel, Delcrest.
India	Harrison's Special Chatham, Delcrest.
Japan	Bright Yellow, Golden Special.

Among the varieties compared it was found that Virginia Gold, Delcrest (Canada), White Gold, N. C. 95, Coker 140 and Golden Special performed best (1). Some of these varieties, however, had to be abandoned subsequently as they were not favoured by the manufacturers. Among these varieties were Virginia Gold and Coker 140 which were outstandingly high yielding.

Finally, the varieties Delcrest, White Gold and N. C. 95 were selected for test against Harrison's Special. This paper deals with the experiment conducted to study the performance of these four varieties of tobacco and their response to nitrogen.

MATERIAL AND METHODS

The experiment was conducted in a rice field at the Agricultural Station, Hingurakgoda during the 1966 Yala season. The upper reaches of the land possessed excellent drainage whereas conditions in the lower section were marginal for drainage.

The cropping history of the experimental land was as follows:—

Season	Crops	Fertiliser applied in lbs. per acre		
		Ammonium sulphate	Sapthos phosphate	Muriate of Potash
Yala 1964	Paddy (H-4)	168	112	56
Maha 1964-65	do.	168	112	56
Yala 1965	do.	224	112	56
Maha 1965-66	do.	224	112	56

Experimental Treatments:

A. Varieties

- V1 — Delcrest
- V2 — White Gold
- V3 — N. C. 95
- V4 — Harrison's Special

B. Nitrogen Levels

- No—No Nitrogen
- N1—20 lbs. Nitrogen per acre.
- N2—40 lbs. Nitrogen per acre (Nitrogen was applied in the form of ammonium sulphate 20.6 per cent N.)

A 4 X 3 factorial design was employed. The experiment had three replicates. Replicates I and II were planted in the well drained area and replicate III was laid in the lower section of the field (Marginal for drainage conditions).

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Each plot (treatment) measured 15' × 30' (i.e. 5 rows of 12 plants each at a spacing of 3' × 2½'). The nett harvested area after leaving a border row of one plant all round, was 3 rows of 10 plants (1/200 acre).

The plots received the different nitrogen levels according to design. In addition, concentrated superphosphate (42 per cent. P_2O_5) at 200 lbs. per acre rate and sulphate of potash (48 per cent. K_2O) at 125 lbs. per acre rate were applied uniformly to all the plots. The fertilisers were applied all at the time of planting, in bands on either side of the plants 4 inches away from the base and 5 inches deep.

Selected seedlings of uniform growth and condition were planted on 18.5.66. Standard cultural practices were followed. The experiment was irrigated on 6.6.66, 22.6.66 and 13.7.66. The harvest was taken in 8 primings and uniformly ripe leaves were harvested in each pick. The green leaf was cured in a conventional flue-barn (16' × 16' × 16') after recording weights of each plot. A curing schedule suitable for the area was employed. The cured leaf was graded according to the buyers' grades by trained graders under supervision and recorded.

At the latter stages of growth some plants in the trial area were affected by root disease—identified by the Plant Pathologist as *Scelerotium rolfsii*. Sacc. (Southern Stem and root rot). There were differences in the susceptibility of the different varieties as indicated by the percentages of plants affected given below:—

The data on rainfall during the experiment was as follows:—

<i>Delcrest</i>	<i>White Gold</i>	<i>N. C. 95</i>	<i>H. S.</i>
5.5%	4.4%	2.7%	2.2%

The percentage of vacancies in replicate III were:—

<i>Delcrest</i>	<i>White Gold</i>	<i>N. C. 95</i>	<i>H. S.</i>
17.7%	20 %	4.4%	17.7%

The Data on rainfall during the experiment was as follows:—

Crop Phase	Rainfall in ins.	No. of rainy days
Pre-nursery (8.2.66 to 7.4.66)	7.15	16
Nursery and transplanting (8.4.66 to 18.5.66)	5.51	10
Growth period (19.5.66 to 20.7.66)	0.21	1
Harvesting and curing (21.7.66 to 2.10.66)	8.46	10
Total	21.14	46

The rainfall during the growth phase was below that required for a good crop of tobacco.

RESULTS

The effects of the different treatments on the early growth of the plants were studied by visual rating of the plots 40 days after transplanting based on the growth and vigour of the plants within a maximum score of 10 and by counting the number of leaves per plant at that stage of growth. The leaf count was taken from 3 randomly selected plants per plot and the number of leaves up to the bud were counted leaving 3 sand leaves at the bottom. The data are presented in tables 1 and 2.

The number of curable leaves which determine to a large extent the green leaf yield per acre, were recorded from 3 randomly selected plants under each treatment at the time of topping. The results obtained are shown in table 3.

The average plot yields of green and cured leaf tobacco computed on the acre basis are shown in tables 4 and 5. The curing out-turn (ratio of green : cured leaf) computed on these figures is indicated in table 7.

The cured leaf was graded according to the standard grades and valued on the basis of the prices fixed for the different grades in 1966. The data are presented in table 6.

As the percentage recovery of leaf lamina is an important criterion in flue-cured tobacco, the treatment effects on strip yield were also ascertained. The cured leaf from the different treatments of replicates I and II were pooled after taking all records and the strip yield percentages (table 8) were determined from the pooled leaf. The stripping was done by carefully removing the mid-ribs from the lamina up to the point near the apex of the leaf where it breaks.

DISCUSSION

Among the environment factors which play a determining role on the yield and quality of flue-cured tobacco, the drainage characteristic of the soil exert a profound influence on the crop. Tobacco soils must possess excellent drainage, both surface and internal (3). Unfortunately under riceland conditions, there is a tendency to grow tobacco in lands which are marginal for drainage. It was in order to quantitatively assess and demonstrate the performance of the varieties under these conditions that replicate III of the experiment

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was planted on the lower section of the field under conditions of marginal drainage. Replicates I and II were on the upper reaches of the field having excellent drainage.

The analysis of the results have shown that the crop grown under good drainage conditions is superior to that grown under poorly drained conditions. This is illustrated by the summarised data presented below :—

Condition of land		Green leaf lbs. acre	Cured leaf lbs. acre	Acre value in rupees
(a) Well drained ..	..	8,031 ..	1,413 ..	4,151
(b) Poorly drained ..	..	4,296 ..	721 ..	2,118
Ratio (a/b) ..	..	2.21 ..	1.94 ..	1.96

The effects of the two soil conditions on the acre values of the varieties were as follows :—

Condition of land		Acre values in rupees			
		V1	V2	V3	V4
a) Well drained ..	..	4900 ..	4393 ..	4271 ..	3037
(b) Poorly drained ..	..	2210 ..	2176 ..	2501 ..	1584
Ratio (a/b) ..	..	2.21 ..	2.01 ..	1.70 ..	1.91

The above results clearly demonstrate the importance and practical value of good drainage condition of soil to the tobacco grower. The superior performance of the varieties Delcrest and White Gold under better conditions of drainage is also shown.

Varieties

The farmer is most concerned with the economic returns from the crop he produces. In the case of flue-cured tobacco this depends on the yield and on the quality of the leaf produced. In local market practice quality is evaluated on the basis of the buyers' grades, which takes into account the colour, body, texture, freedom from blemishes, aroma, etc., of the cured leaf. In selecting a suitable variety with a view of obtaining maximum economic returns, uniformity of maturity, curing out-turn, strip yield and disease resistance are important considerations.

The results presented in table 6 show that the three varieties, Delcrest, N. C. 95 and White Gold are significantly superior at 1 per cent level to the variety Harrison's Special in the *monetary return per acre*. Delcrest showed an income superiority over Harrison's Special by 57 per cent while N.C. 95 and White Gold were superior by 44 per cent and 43 per cent respectively. The three superior varieties are, however, not significantly different from each other.

In respect of *cured leaf yield* per acre also the varieties performed in the same order (table 5) as above.

In the *average value per pound* of cured leaf Delcrest was almost on par with White Gold. The prices were Rs. 3.06 and Rs. 3.08 respectively. The value per pound of N.C. 95 was Rs. 2.89 while that of Harrison's Special was Rs. 2.63.

The varieties have, however performed differently in respect of the other characteristics studied in this experiment.

Plant vigour in the early stages of growth is desirable for the early establishment of the crop in the field, even under adverse conditions. The rating given and the leaf count taken at 40 days after planting (tables 1 and 2) show that White Gold has a significantly better early growth than the other varieties tried. The variety N.C. 95 was the slowest in early growth. Thus in the field, it is likely that the farmer will be much impressed with the variety White Gold in the early stages of growth. It was found, however, that by topping time the early response had evened out and N.C. 95 had caught up with the other varieties in the trial (table 3). Though the variety Harrison's Special showed a significantly large *number of leaves* at the time of topping, yet in the yield of green leaf, cured leaf and monetary return per acre it ranked lowest. The seeming good performance of the Harrison's Special variety in the field which had so far found favour with the growers is thus deceptive.

A variety having a better *curing out-turn* is of considerable agromomic significance because it would reduce the harvesting and curing expenses. Under the local practice of flue-leaf production the barn owner who buys the green leaf would also be most concerned about the curing out-turn of a variety. The data obtained in this experiment (table 7) though not significant, indicates that the curing out-turn of the varieties are in the following order:—

Delcrest, White Gold, N.C. 95, Harrison's Special.

Strip yield of tobacco is of immense value to the manufacturer and the tobacco exporter; a higher percentage of strip means a bigger out-turn of manufactured product and a better economic return. Mid-ribs are different from the lamina in both chemical constituents and smoking flavour (4). The stem is generally less usable in manufacture of cigarettes. On the basis of a study of strip yield of flue-cured tobacco in relation to certain chemical characteristics, Jenkins *et al.* (5) suggested that the percentage of strip yield may be useful as an additional measurable character in the evaluation of

flue-cured tobacco varieties and breeding lines. The variety Delcrest gave the highest percentage of strip yield (76.3 per cent) with White Gold coming second (74.1 per cent). The varieties N.C.95 and Harrison's Special performed equally giving 71.8 per cent. and 71.7 per cent respectively (table 8). (In the experiments of Jenkins *et al.* (5) in Georgia the strip yield of N.C. 95 had ranged from 72.2 per cent-72.4 per cent.)

The results demonstrate that the variety Delcrest has out-yielded the other varieties tested out and given the highest income per acre, and also has shown superiority in the other important characteristics studied. However, because the differences in performance between Delcrest and the other two superior varieties (N.C. 95 and White Gold) are not significant, any one of these three varieties could profitably replace Harrison's Special under irrigated conditions in the Dry Zone ricelands of Ceylon. The choice of a variety will depend on special conditions of the area. Delcrest and White Gold would respond better under better drainage. As N.C. 95 has been reported to be resistant to root diseases, specially root knot (6), it may be expected that this variety would do better in areas where root diseases are a problem. In a survey conducted by the Plant Pathologist, Department of Agriculture, Ceylon, in 1965-66 (7), it has been shown, however, that N.C. 95 had some resistance to bacterial wilt but was susceptible to leaf diseases such as mosaic, leaf curl and yellow net virus when compared with the variety Harrison's Special.

Nitrogen

Nitrogen has a marked effect on the growth and yield of crops. In flue-cured tobacco it has been recognized as the most critical major nutrient. Excess nitrogen results in rank tobacco with cured leaf of low quality, dull in colour, poor in texture, high in nicotine content and low in sugar (flue-cured tobacco is regarded as low nitrogen and high sugar tobacco). Certain diseases are also severe in tobacco crops liberally supplied with this element. On the other hand, inadequate nitrogen results in tobacco low in both yield and quality. For flue-cured tobacco it has been more difficult to determine the amount of nitrogen and time for its application than in the case of the other nutrients. Garner has reported that on an average soil flue-cured Virginia tobacco requires about 24 pounds of available nitrogen per acre for the production of highest quality leaf (3).

In this experiment the response shown by the different varieties on the yield and quality of the leaf to varying levels of nitrogen

is not statistically significant (tables 5 and 6). It is observed, however, that above 20 pounds nitrogen per acre has depressed monetary return except in the case of the variety Delcrest which has shown a visual response to levels of over 20 pounds.

A noteworthy point that appears from the results shown in figure 1 is the relative lack of response of the variety Harrison's Special (on which the local cigarette tobacco industry has for so long depended) to applications of nitrogen. The other three varieties showed some response to nitrogen at 20 pounds per acre. The variety Delcrest would seem to be most promising under better conditions of higher nitrogen fertilization.

Summarized data giving the influence of nitrogen on the different crop characteristics studied in this experiment are presented below :—

	0 lb. N/acre	20 lb. N/acre	40 lb. N/acre
No. of leaves per plant at 40 days	7.50	8.83	9.25
Average number of curable leaves per plant	18.45	19.53	19.46
Weight of green leaf (pounds per acre)	6,150	6,896	7,313
Weight of cured leaf (pounds per acre)	1,055	1,263	1,228
Acre value (in rupees)	3,169	3,734	3,516
Strip yield (percentage)	73.6	74.5	72.6
Curing out-turn (ratio of green : cured leaf)	5.98	5.48	6.09

It would appear from the foregoing that considering the overall performance of the varieties in respect of acre value, cured leaf yield, strip yield and curing out-turn, nitrogen levels above 20 pounds per acre have little beneficial effect on the crop, and may actually give poor economic returns. In this experiment, the increase in the green leaf yields for nitrogen levels above 20 pounds per acre has given no compensatory increase in income.

On the results of a series of experiments over 13 seasons in Rhodesia Salmon (8) reported that there was not much response to applications of over 20 pounds nitrogen per acre and that the results were variable. He concluded that recommendations regarding nitrogen fertilization are difficult unless answers to fundamental questions on nutrient availability and uptake are known. In India too, applications of over 20 pounds nitrogen per acre for cigarette tobacco have not been found to be beneficial (9). About 20 pounds nitrogen per acre is the general recommendation for flue-cured tobacco in many parts

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of the world except in the relatively sandy soils low in organic matter in the tobacco growing areas of America where higher doses (30-40 lb. N) are given. Under conditions of this experiment, in the ricelands of the Dry Zone the recommendation of the Department of Agriculture has been generally 20 pounds nitrogen per acre.

SUMMARY

The performance of four flue-cured (cigarette) tobacco varieties and their response to nitrogen under controlled irrigation in the Dry Zone riceland at Hingurakgoda were studied. The results show that the varieties, Delcrest, N.C. 95 and White Gold can profitably replace the long standing variety Harrison's Special. There was no significant difference between the performances of these three better varieties. However, under conditions of better management, Delcrest has consistently shown superiority. As N.C. 95 is reputed to be resistant to nematodes and certain root diseases this variety could preferably be used wherever these diseases are important. White Gold would appear to do well under general conditions and in areas where conditions for early growth are favourable.

The results obtained regarding the response to different levels of nitrogen on the yield and quality of flue-cured tobacco were consistent with those of similar experiments carried out earlier. The indication is that about 20 pounds of nitrogen per acre would give the most economic returns for the well drained loamy rice soils of the Dry Zone. The variety Delcrest shows response to higher levels of nitrogen and will have to be further studied.

ACKNOWLEDGMENTS

The authors wish to thank Mr. K. H. N. S. Seneviratne, Manager, Agricultural Station, Hingurakgoda, for providing the necessary facilities to carry out the experiment and to Mr. M. E. R. Pinto of the Horticulture Division for his valuable help in the statistical computations. We are also grateful to Dr. M. W. Thenabadu, Acting Chemist, for critical examination of the script.

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TABLE 1. —Rating of the plots at 40 days

<i>Variety</i>	<i>Mean</i>	<i>Nitrogen Level</i>	<i>Mean</i>
White Gold (V2)	.. 8.56	40 lb. nitrogen per acre	.. 8.42
Delcrest (V1) ..	.. 7.78	20 lb. nitrogen per acre	.. 7.83
Harrison's Special (V4)	... 7.56	0 lb. nitrogen per acre	.. 6.67
N. C. 95 (V3)	.. 6.67		

L.S.D. (5%) 1.28

L.S.D. (5%) 1.11

C.V.=17.1%

TABLE 2.—Number of leaves per plant at 40 days after transplanting

<i>Variety</i>	<i>Mean</i>	<i>Nitrogen Level</i>	<i>Mean</i>
White Gold (V2)	.. 9.67	40 lb. nitrogen per acre	.. 9.25
Delcrest (V1)	.. 8.78	20 lb. nitrogen per acre	.. 8.83
Harrison's Special (V4)	... 8.78	0 lb. nitrogen per acre	.. 7.50
N. C. 95 (V3) ..	.. 6.89		

L.S.D. (1%) 1.32

L.S.D. (5%) 1.14

C.V.=15.8%

TABLE 3.—Number of curable leaves per plant

<i>Variety</i>	<i>Mean</i>	<i>Nitrogen Level</i>	<i>Mean</i>
Harrison's Special (V4)	.. 20.20	20 lb. nitrogen per acre	.. 19.53
N. C. 95 (V3)	.. 19.01	40 lb. nitrogen per acre	.. 19.46
White Gold (V2)	.. 18.76	0 lb. nitrogen per acre	.. 18.45
Delcrest (V1)	.. 18.26		

L.S.D. (1%) 0.95

L.S.D. (5%) 0.82

C.V.=5.07%

TABLE 4.—Yield of green leaf (lb. per acre)

<i>Variety</i>	<i>Mean</i>	<i>Nitrogen Level</i>	<i>Mean</i>
N. C. 95 (V3)	.. 7406	40 lb. nitrogen per acre	.. 7313
Delcrest (V1)	.. 7211	20 lb. nitrogen per acre	.. 6896
White Gold (V2)	.. 6517	0 lb. nitrogen per acre	.. 6150
Harrison's Special (V4)	.. 6011		

L.S.D. (5%) 1,000lb. per acre

L.S.D (5%) 865 lbs. per acre

C.V.=15.1%

TABLE 5.—Yield of cured leaf (lbs. per acre)

<i>Variety</i>	<i>Mean</i>	<i>Nitrogen Level</i>	<i>Mean</i>
Delcrest (V1)	.. 1305	20 lb. nitrogen per acre	.. 1263
N. C. 95 (V3)	.. 1272	40 lb. nitrogen per acre	.. 1228
White Gold (V2)	.. 1186	0 lb. nitrogen per acre	.. 1055
Harrissons Special (V4)	.. 966		

L.S.D. (5%) 246 lb.

Not significant

C.V.=21.3%

TABLE 6.—Value of produce (Rupees per acre)

<i>Variety</i>	<i>Mean</i>	<i>Nitrogen Level</i>	<i>Mean</i>
Delcrest (V1)	.. 4004	20 lb. nitrogen per acre	.. 3734
N. C. 95 (V3)	.. 3681	40 lb. nitrogen per acre	.. 3516
White Gold (V2)	.. 3655	0 lb. nitrogen per acre	.. 3170
Harrison's Special (V4)	.. 2553		

L.S.D (1%) 751 Rs./acre

Not significant

C.V.=20.06%

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TABLE 7.—Curing out-turn (Ratio of green : Cured leaf)

<i>Variety</i>	<i>Mean</i>	<i>Nitrogen Level</i>	<i>Mean</i>
Delcrest (V1)	.. 5.57	20 lb. nitrogen per acre	.. 5.48
White Gold (V2)	.. 5.87	0 lb. nitrogen per acre	.. 5.98
N. C. 95 (V3)	.. 5.83	40 lb. nitrogen per acre	.. 6.09
Harrison's Special (V4)	.. 6.33		

Not Significant

C.V. = 15.2%

TABLE 8.—Percentage strip yield

<i>Variety</i>	<i>Mean</i>	<i>Nitrogen Level</i>	<i>Mean</i>
Delcrest (V1)	.. 76.3	20 lb. nitrogen per acre	.. 74.5
White Gold (V2)	.. 74.3	0 lb. nitrogen per acre	.. 73.6
N. C. 95 (V3)	.. 71.8	40 lb. nitrogen per acre	.. 72.6
Harrison's Special (V4)	.. 71.7		