The Effect of 2,3-Dichloro-1,4-Naphthoquinone on Maleic Hydrazide Treated Greenhouse-Grown Tobacco[1]

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Introduction

Elimination of hand suckering of tobacco by treatments with maleic hydrazide (1,2-dihydropyridazine-3, 6-dione) (MH) is widely favored by tobacco growers. This practice tends to increase tobacco yields and dollar returns per acre without measurably reducing grade values and prices, as shown by Gaines (1959). Absence of sucker growth will also be essential if and when the mechanical harvesting is adopted by tobacco growers.

From the manufacturer's standpoint these factors often do have little meaning, as other considerations are of greater importance. It is known that under cultural practices the use of MH increases the sugar content and the sugar-nicotine ratio and reduces the specific volume and nicotine content of flue-cured tobacco (Vickery, 1959). Similarly, more comprehensive results have been obtained by Coulson (1959), who stressed the economic importance of loss of filling value and the disturbance in the balance of the main chemical components in the leaf. Birch and Vickery (1961) also concluded that application of MH to flue-cured tobacco brought about changes conducive to an impairment of quality.

In view of the potential benefits to the farmers which the use of MH offers, the overcoming of its adverse effects on quality from the manufacturer's standpoint is extremely important. The problem has been to find a chemical agent or agents acceptable to tobacco growers and manufacturers alike, which, if sprayed or otherwise applied to tobacco, would reduce the undesirable effects of MH without impairing its plant growth regulatory activity.

This investigation reports on the use of napthoquinone (NQ), (2,3-dichloro-1,4-napthoquinone) in conjunction with MH on greenhouse grown flue-cured tobacco and the subsequent changes in leaf properties.

Materials and Methods

Flue-cured tobacco, (*Nicotiana tabacum*, L.) var. Hicks, was grown in greenhouse in 2-gallon glazed pots in soil. The plants were topped high and were sprayed with aqueous solutions of MH and NQ with an addition of a few drops of Tween 20. Under the conditions of this experiment, each plant had 12 to 13 leaves at the beginning of treatments. The treatments were: 1) MH, in the rate of 2.25 lbs. of MH per acre; 2) MH, 2.25 lbs. of MH per acre +2.5 lbs. of NQ per acre; 3) MH, 2.25 lbs. of MH per acre +7.5 lbs. of NQ per acre; 4) NQ, 2.5 lbs. per acre; 5) NQ, 7.5 lbs. per acre, and 6) check. MH was applied immediately after topping. The amounts of MH and NQ used were calculated, taking into account the relatively small size of greenhouse-grown plants in comparison to the field-grown tobacco. The whole amount of NQ was applied the day following topping in the treatments 2 and 4. In treatments 3 and 5 the amount of NQ was divided in three parts of 2.5 lbs. per acre each. The first application was made as in treatments 2 and 4 and was followed by two 2.5 lbs. per acre treatments at weekly intervals. The second application of NQ was made after the first priming and third after the second priming. There were from 10 to 11 leaves left after the first priming and from 7 to 8 after the second one. There were four single plant replicates arranged randomly. The leaves were harvested as they ripened, two to three per priming, and were cured in a controlled temperature and humidity chamber. Sucker growth was removed twice after the third and the fifth, final priming in treatments where MH was not used and once, after the fifth, final priming in treatments including MH. The weight of leaves and suckers and the chemical constituents analyzed were calculated on oven-dry matter basis. A representative sample of leaves was ground coarsely and the size fraction of 20 to 28 mesh used for analyses of filling power and equilibrium moisture content. For determination of equilibrium moisture content the samples were equilibrated at 75 per cent of relative humidity and room temperature. Filling power was determined at arbitrarily set conditions where the tobacco sample was equilibrated as in tests for moisture equilibrium. Two grams of moist, equilibrated tobacco were measured into a volumetric centrifuge tube and

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Table 1. Some chemical and physical analyses of flue-cured tobacco treated with maleic acid hydrazide (MH) and 2,3-dichloro-1,4-naphthoquinone (NQ).

	MH	MH+NQ (2.5 lbs/a)	MH+NQ (7.5 lbs/a)	NQ (2.5 lbs/a)	NQ (7.5 lbs/a)	Check	"F"
Sucker growth, gm per plant	8.00	9.34	5.65	34.08	33.53	31.80	14.95^{xx}
Yield, gm per plant	35.10	27.93	27.10	13.32	15.70	16.40	6.16^{x}
Sugars, %	38.64	32.89	27.76	21.37	18.86	32.17	5.07^{x}
Total alkaloids, %	2.13	2.10	2.26	2.10	2.11	2.20	—
Nicotine, %	2.10	2.04	2.20	2.04	2.06	2.16	—
Sugar-nicotine ratio	18.1	15.6	12.3	10.2	8.9	14.6	—
Chlorine, %	1.06	1.17	1.27	1.55	1.68	1.46	4.42^{x}
Equilibrium moisture content, % at 75% R.H.	29.32	27.43	27.51	24.33	24.75	26.20	2.22
Filling power, ccm per 2 gm of tobacco at 75% R.H.	6.51	7.10	7.18	8.05	8.64	7.76	2.90

Necessary "F" 5% 3.69; 1% 6.63

centrifuged in International Centrifuge, Model SBV, for 10 minutes at 800 r.p.m. The volume of tobacco, after centrifuging, in ccm, was taken as the measure of filling power. The remaining portion of leaves was ground finely in a Wiley Mill and analyzed for sugars, alkaloids, and chlorine. Sugars were determined by the method of Hiscox (1942), alkaloids by method of Cundif and Markunas (1955) and chlorine according to procedure by Samson (1953). The data were analyzed statistically.

Results and Discussion

The results are presented in **Table 1**. Weight of suckers was very significantly reduced by MH treatments with or without additions of NQ. In other words, NQ treatments did not affect the sucker-growth controlling properties of MH. Yield of cured leaves was affected oppositely: where MH was used the yield was significantly higher than in those treatments where it was omitted. Yield of leaves in treatments where NQ alone was used did not differ from the check treatment. NQ, together with MH, did not decrease the yield of cured leaves. Total alkaloid and nicotine content was not influenced appreciably by MH or by NQ treatments. In respect to MH this is contrary to reported evidence for field-grown tobacco (Birch and Vickery, 1961) and may perhaps be explained by the confinement of root tip growth within the enclosed space in the pots. Another explanation may be that possibly a part of the nicotine in the leaves from NQ treatments, and the check, went into the suckers and would have been higher, percentage-wise, if sucker growth had been more normally balanced with leaves. Under such conditions the effect of NQ in restoring the nicotine content of the leaves, also conversely the effects of MH in reducing the nicotine content, might have been much greater. MH treatments increased the sugar content significantly over NQ, and over MH and high dose NQ treatments (treatment 3). The differences in sugar content between check and NQ treatments were significant: NQ treatments decreased the sugar content. NQ in combination with MH restored the sugar content close to that of the check and below that of MH treatment; thus this overcomes one of the major drawbacks of MH.

Sugar-alkaloid ratios followed the trend of sugar percentages. The ratio was high in the MH-treated leaves and was lowered by NQ treatments and maintained near that of the check by combining MH and NQ applications. MH treatments significantly decreased the chlorine content of leaves as compared with the check. NQ treatments raised the chlorine percentage of leaves significantly above the MH treatments. MH and NQ together also raised the chlorine level in leaves, although not significantly. The increase in chlorine level with NQ treatments may be accounted for by the chlorine in the formula of NQ, (2,3-dichloro-1,4-naphthoquinone). The equilibrium moisture content and filling power values were not statistically significant. Nevertheless, definite trends were evident: MH treatment increased the equilibrium moisture content and decreased the filling power of the cured leaf as compared with the check. This was reversed by the NQ treatments with the equilibrium moisture content being decreased and the filling power increased. NQ in combination with MH reversed to a large extent the effects of MH when it was used alone. The interdependence of equilibrium moisture content and filling power has been described previously by Sedlatschek (1957). In addition to the analyses reported in **Table 1** and described above, a few tests were made on the content of petroleum ether extracts and color. The data indicate that NQ treatments increased the petroleum ether extract content of cured leaves and slightly darkened the tobacco. The first property is desirable, while the second is not, and may require adjustment of the cultural and curing practices of flue-cured tobacco. Redox potential, oxygen tension and concentration of phenolases and reductases in the plant tissues are possible factors in the color reaction. Other quinone derivatives should be tested as to their influence on tobacco color. Control of the color phenomena may result from control of these factors.

The acceptability of quinones and naphthoquinones by tobacco consumers and manufacturers has yet to be assessed. In this respect it may be stated that napthoquinones, although not the 2,3-dichloro-1,4-naphthoquinone, are natural constituents of green plants: many if not all green parts of plants contain vitamin K, or phylloquinone, a derivative of 1,4-naphthoquinone (Schwarze, 1958). The natural occurrence of quinones in plants should remove any objections to their use.

The influence of NQ on the physical and chemical properties of the MH-treated tobacco plants has not been reported previously. The economic importance of this finding cannot be over-stressed: the obvious increase in yield of tobacco, and decrease in cost of labor by use of MH may be utilized and the undesirable effects ameliorated by joint use of MH and NQ. Use of MH and NQ in combination should also make the advance of mechanical harvesting of tobacco feasible and acceptable. The use of NQ, especially if multiple spraying is required, may raise the costs of tobacco production but this should be greatly outweighed by increased acceptability of MH treated tobacco.

Field experiments are being conducted on the use of MH and NQ on tobacco. Similarly, the use of other quinones and naphthoquinones and their derivatives is being explored, as is the mode of action of these chemicals. It is expected that results of these experiments will be reported at a later date.

Summary

2,3-dichloro-1,4-naphthoquinone was found to decrease the sugar, equilibrium moisture content and the sugar: nicotine ratio, and increase the filling power and chlorine content of flue-cured tobacco. Additions of 2,3-dichloro-1,4-naphthoquinone to maleic hydrazide sprays in control of tobacco sucker growth counteracted the effects of maleic hydrazide on filling power, sugar, nicotine, equilibrium moisture, and chlorine content of tobacco. The sucker growth inhibitory action of maleic hydrazide was not affected by this chemical.

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