ORIGINAL CONTRIBUTIONS

STUDIES ON THE OIL AND AMMONIA CONTENT OF COTTONSEED. PROGRESS REPORT ON BASIC RESEARCH PROBLEM I

By A. F. Sievers

One of the research projects suggested by the Committee on Basic Research in Oils and Fats at Washington in October, 1921, was as follows: "To develop varieties of cotton that will yield fibre of maximum value and seed containing the maximum percentage of oil; and also to determine the effects of cultural conditions." This problem was assigned to the Bureau of Plant Industry. The problem of developing varieties of cotton suitable to the several sections of the cotton area has been a major project of the Office of Crop Acclimatization of that Bureau for many years and results on such researches have been published from time to time by Dr. O. F. Cook and his associates. A comprehensive study of the oil content of the cottonseed and its relationship to the many factors involved in the cultivation of this plant is a new undertaking by the Department and it is on the progress of this feature of the basic research problem mentioned that I wish to report to you at this time.

It is probably unnecessary to say that the very nature of the investigation is such that no immediate results can be expected. The work for one season may be very comprehensive and the data obtained quite conclusive, but the fact that we are dealing with a crop that is subject to the influence of climatic and cultural conditions, which may vary from year to year, makes it obvious that the results of a single year or even of several years can be considered only with certain reservations. It is for this reason that in this year's report varieties and stations will not be referred to by name but by symbol and a general summary will be given of the conclusions indicated by the results obtained in so far as they apply to a single year.

The oil content of cottonseed has been the subject of considerable study by some of the Experiment Stations and it is doubtless true that those phases of the problem which concern themselves with the several varieties and with the regional conditions of an individual state can well be undertaken by the Experiment Stations. It is seldom, however, that such a station can conduct its investigations outside the limits of the individual state. The first consideration, therefore, in outlining the program in the Department of Agriculture was to make it interstate in character in the hope that eventually the data thus accumulated might reveal the basic truths regarding the relationship of lint and oil value of cottonseed under the widely divergent conditions obtaining in the entire cotton belt.

It is impossible in a brief report to describe the investigations undertaken at the several Experimental Stations and by other investigators, but it may be well to summarize briefly some of the conclusions drawn from these investigations as obtained from a study of the published reports. It appears to have been concluded that when grown under different conditions certain varieties will rank differently as regards the oil content of their seed; that rainfall has a decided influence on the oil content and that environmental factors such as soil and climate cause a greater difference in the composition of the seed than is due to varietal characters alone. Probably the most important indication is that the greatest single factor affecting the oil content is the maturity of the seed. Immature seed means a lower per cent of kernels and consequently a lower oil content.

In undertaking the study of the seed the Office of Drug, Poisonous and Oil Plant Investigations effected a coöperation with the Office of Crop Acclimatization in order that the latter's field organization might be available for securing the samples. It was arranged therefore, to include samples from a total of 29 varieties grown at 10 different stations as follows: one each in Virginia, Kansas, Oklahoma, New Mexico and Arizona, two in Texas and three in California. The Virginia and Kansas stations represent regions of considerable rainfall; the Texas and Oklahoma stations those of a more limited rainfall, while the far western stations were under irrigation. Although it would have been desirable to include several locations in the southeastern area, time was not available to make the necessary arrangements for last year's season.

The samples of seed were sent to the laboratory from the several stations in friction top tin cans. Some of the samples were sent as seed cotton and were ginned in a hand gin in the Department. The following analyses were made; moisture, average weight of the seed, per cent of kernels, per cent of linters, per cent of oil, and per cent of ammonia. The ammonia determinations were all made by the Barrow-Agee Laboratories at Memphis. Owing to the fact that several sets of samples were ginned by different individuals it was decided at the outset that oil determinations made on the whole seed would probably give unreliable results since it was found that samples from the different stations did not appear to be ginned alike. Consequently the oil determinations were made on naked seed. The available sample of seed was freed from foreign matter and a representative 15 gm. sample selected and delinted with concentrated sulphuric acid. The seed was thoroughly washed to remove the acid and dried for five minutes in a revolving metal cage in a current of air from an electric fan. It was then weighed to determine the per cent of linters and fuzz. The naked seed was then dried moisture-free and again weighed and then extracted with petrolic ether in accordance with the practice in the commercial laboratories. Some question may be raised as to the accuracy of

the sulphuric acid method of delinting the seed but preliminary trials on a uniform lot of seed indicated that with carefully controlled and uniform technique very concordant results can be obtained. Any error resulting from this method would at any rate be much smaller than the error resulting from making the oil calculations on the basis of the whole seed when such seed is not uniformly ginned. All the data are at hand, however, for making the latter calculations if so desired.

It is to be regretted that of the 10 stations only 3 sent samples from the full set of 29 varieties, and from no station were samples obtained from less than 19 varieties. On the other hand, all the stations furnished samples from 8 of the 29 varieties, but from no variety were samples obtained from less than 5 stations. This lack of complete representation of all the varieties from all the stations has greatly complicated the correlation of the data. Comparisons from several angles were necessary in order that conclusions indicated by general and simple averages might be corroborated. The first inspection of the data consisted of arranging the results in a series of 14 tables in each of which from 5 to 10 stations were compared but in which only those varieties were compared which furnished samples from those particular stations. Thus, in one group 24 varieties are compared from stations A, D, F, G, and H. This group represents a comparison of the maximum number of varieties from at least 5 stations. On the other hand in another group only 8 varieties are compared but the comparison covers all the 10 stations. The purpose of these groupings was to avoid comparing averages from several varieties, for example, unless they were represented at the same station. It was found, however, that deductions drawn from such group comparisons were almost in complete harmony with those drawn from the simple averages.

The analyses were studied from the standpoint of the oil content of the moisture-free delinted seed. On this basis it was found that the 29 varieties could be grouped into three groups, representing varieties of high, medium and low oil content, respectively. As an arbitrary division 9 high, 11 medium, and 9 low oil yielding varieties were designated.

A number of interesting facts are revealed by a study of these three groups. It was noted that the average percentage of oil in the delinted seed of the high varieties was 24.31 while that for the low varieties was 22.43, the difference being 1.88 per cent. If the average oil content of only the four highest oil-yielding varieties are compared with the average oil content of the four lowest varieties the difference is 3 per cent instead of 1.88 per cent. If the calculations are made on the basis of the whole seed the difference in the averages are substantially the same. In this connection it may be stated that among all the varieties and at all the stations the highest oil content noted in the delinted moisture-free seed was 31.74 per cent, while the lowest noted was 15.29 per cent. The variety giving

this high yield at one station yielded only 16.01 per cent at another station, this being a difference of almost 100 per cent. On the other hand, the variety giving the lowest yield of the entire list gave at one station a yield of 28.68 per cent. These figures are quoted merely to show the wide range in the oil content of the seed obtained from the several stations under the conditions which prevailed during the past season. It is quite impossible, however, to convey in this report, without lengthy tabulations, the regularity with which the high and low yielding varieties fall into the high and low groups at the several stations.

Other investigators have pointed out that the percentage of kernel in the seed is an important factor in the yield of oil. This is of course to be expected since the oil resides in the kernel. The percentage of kernels is naturally greater in that seed which is partially naked, such as Meade, Pima, and Seabrooke, but when the oil calculations are made on the delinted seed this factor is eliminated. There still remains, however, the effect of the ratio of kernel to hull. A seed with a thick hull or a poorly developed seed yields a lower percentage of kernel than a thin hulled or a well matured seed. It was observed that the seed in the high oil group contains 3 per cent more kernel than the seed in the low oil group.

In order to determine to what extent the relationship of hulls to kernels might be responsible for the grouping of the several varieties into high and low oil yielding seed the kernels or meats from four of the highest and four of the lowest varieties from the several stations were extracted. The results have not been completely correlated but they plainly indicate that, with few exceptions, the kernels from the high oil varieties actually contain more oil than the kernels from the low oil varieties. They show, furthermore, that the seed from those stations where unfavorable conditions prevented full maturity or full development being attained, the low oil content of such seed is due in part to unfilled hulls and in part to less oil in the kernels. The important fact is that at those stations where all the varieties produced plump and fully matured seed the kernels of the seed in the high oil group showed a distinctly higher oil content than those from the low oil group. This is the basis on which all attempts to differentiate between oil values of the seed of the several varieties must rest because it is less subject to modifying factors than any other basis of comparison.

The average weight of the seed, so far as indicated by the data available, appears to be of minor importance. In fact the average weight is slightly higher for the low oil group than for the high oil group. Important consideration must be given here to the lack of uniformity in the ginning which fact probably makes this data of doubtful value except for comparison with the percentages of oil and ammonia when calculated on the whole seed basis.

The relationship of the ammonia content of the seed to its oil content is

of much importance since it is these two constituents which largely measure the commercial value of the seed. The ammonia determinations were made in the Barrow-Agee Laboratories on the whole seed and the percentage calculated on this basis as well as on the delinted seed basis. A study of these percentages showed that the ammonia averages of the varieties in the high oil group and the low oil group are almost exactly the same, namely, 4.40 and 4.41 per cent, respectively, based on the whole seed, and differ only by 0.13 per cent when calculated on the delinted seed basis. From this it would appear that when calculated on the entire seed or on the hulls and kernels (delinted seed) the ammonia percentages do not show any characteristic varietal relationship. It appears, however, that there is a fairly definite relationship between the oil and ammonia content of the delinted seed when compared with reference to the points of production. Thus at one station the seed produced was exceedingly rich in oil (27.82%), but in ammonia it was far below that from the other stations (4.14%). On the other hand, at two other stations the seed had a low oil content (19.96% and 20.02%), but a high ammonia content (5.55% and 5.69%). At the station which furnished seed with the lowest oil content (18.64%) this was not accompanied by a correspondingly high ammonia content (4.78%), but at this particular station the short season did not permit the seed to mature fully, thus no doubt affecting its normal composition. The relationship apparently indicated is in accord with the conclusions of other investigators who pointed out that conditions favoring an increased oil development appear to have a contrary effect on the nitrogenous constituents.

As previously mentioned, samples were secured from 10 stations all but one of which are located west of the Mississippi River. The 5 westernmost stations are under irrigation and therefore under artificial control as far as concerns moisture. In one of these stations, as already stated, the season is somewhat short for cotton and the seed received from this station was decidedly immature, being light in weight, low in percentage of kernels, and very low in oil content. In fact, the wide range in oil content shown by practically all varieties is due to the immaturity of the seed from this station. At two stations located in a long established cotton district the season was unfavorable and the seed from these stations was also of poor quality although this was apparently due not so much to a short season as to unfavorable growing conditions. Another station, located in a district which normally has sufficient rainfall during the growing season but which in 1923 had very little rain in midsummer, also produced seed of inferior quality. By far the best seed from all considerations was secured from one of the irrigated stations. This seed was large, fully developed, and its oil content was so markedly high that it far outranks any other station. While this great difference in the quality of the seed produced at the

several stations suggests interesting possibilities it serves well to emphasize the fact that these investigations must necessarily extend over a period of years in order to observe the effect of the changing seasonal conditions. It is not improbable that results obtained from the present year's crop may result in an entirely different ranking of the several stations. This is especially true of those stations which depend on natural rainfall and where the temperature ranges are wide and the growing season more or less changeable. Perhaps the most interesting fact, however, is that under all the diverse conditions obtaining at the stations represented the relative rank of the varieties as regards yield of oil has, with few exceptions, been the same at all the stations. Certainly this should be sufficient basis to justify a continuation of this work over a sufficient number of years to eliminate, as far as possible, those factors which change from year to year and which are not generally subject to control.

In conclusion let it be emphasized that the foregoing observations are entirely from the standpoint of seed values as viewed by the oil miller. When these investigations have been carried far enough to warrant definite conclusions it will then be necessary to correlate the value of the several varieties from this standpoint with the evaluation of these varieties on the basis of lint production and their general adaptiveness to specific locations in the cotton area in order to determine the true value of such varieties to the grower.

CONTRIBUTION FROM BUREAU OF PLANT INDUSTRY,
U. S. DEPARTMENT OF AGRICULTURE

A PROPOSED SUBSTITUTE FOR THE PRESENT OFFICIAL LYE TABLE OF THE I. C. S. C. A.

BY H. J. MORRISON

The official lye table for maximum amounts allowed in refining crude cotton seed oil by the Rules of the Interstate Cotton Seed Crushers Association is based on the amount of NaOH necessary to neutralize the free fatty acid plus certain excesses.

The latter figure increases abruptly at each multiple of two per cent in free fatty acids.

Plotting these figures necessarily gives a zig-zag or saw tooth curve.

If a straight line is drawn through the average of the saw tooth curve, we necessarily have a curve in which the increases in maximum are gradual and violent differences avoided.

The formula for neutralizing is:

$$\frac{\text{F. F. A.}}{7.05} = \%\ \text{dry NaOH}$$