Study on Relationship between Oil, Protein, and Gossypol in Cottonseed Kernels[1]

S.N. PANDEY and **N. THEJAPPA**, Cotton Technological Research Laboratory, Indian Council of Agricultural Research, Matunga, Bombay, 400 019, India

ABSTRACT

Study on interrelationship between oil, protein, and free gossypol in cottonseed kernels of 97 varieties is reported. Relationship between these properties was studied for each botanical species separately, as well as for all the varieties together. Protein and oil were negatively correlated. The correlation coefficients (γ) were significant at the 1% level in the case of *Gossypium arboreum, Gossypium hirsutum,* and *Gossypium barbandense,* as well as for all the varieties combined. In the case of *Gossypium herbaceum* varieties, γ was significant at 5% level. No correlation was found between oil and free gossypol. Protein and free gossypol were negatively correlated. The correlation coefficients were significant at the 1% level in the case of *G. hirsutum, G. barbadense,* and all the varieties combined, while it was significant at 5% in the case of *G. herbaceum* varieties.

INTRODUCTION

Cottonseed is one of the important agricultural commodities in cotton growing countries and is the most widely distributed oilseed in tropical and subtropical areas. It is now more valuable as a source of food, feed, and fiber than ever before. Cottonseed oil and its cake are of great economic value in developing countries. The pigment gossypol influences the color of the oil and the utility of the meal, particularly as a protein-rich feed for monogastric animals as well as for human consumption. It is well known that gossypol reacts with amino acids, such as lysine of the protein, and adversely affects the quality of the cottonseed flour. A number of studies have been reported on chemical constituents of cottonseeds (1-6). Place and environmental effects upon various constituents of cottonseeds have been reported in recent articles (1,7). Literature on the interrelationship between important constituents like oil, protein, and gossypol in cottonseed kernels of different varieties belonging to different botanical species is scanty. In this study, the information on interrelationship between oil, protein, and free gossypol content in cottonseed kernels of Indian cottons belonging to different botanical species, which is reported for the first time, is expected to be of great importance to breeders, cotton growers, and to the cottonseed trade and industry.

[1]Presented at the Golden Jubilee Celebrations of the Indian Chemical Society and the Annual Joint Conventions of Chemists, Calcutta, December 1973.

MATERIALS AND METHODS

The cottonseed samples studied include some of the promising new strains and most of the commercial varieties grown in India. The seed samples were received from different parts of the country from cotton breeders and cotton specialists. In all, 97 seed samples belonging to different botanical species, namely 30 from *Gossypium arboreum,* 11 from *Gossypium herbaceum,* 46 from *Gossypium hirsutum* and 10 from *Gossypium barbadense* were analyzed for oil, protein, and free gossypol.

Seeds were dehulled, separated, and ground. Analysis of oil, protein, and gossypol in ground kernels was carried out according to AOCS Methods Ba-3-38, Ba-4-38, and Ba-7-58 (8) with minor modifications. Data on oil are expressed on 10% moisture basis, and data on protein and free gossypol are expressed on moisture free basis.

RESULTS AND DISCUSSION

Oil in Kernels

The species-wise and combined ranges and average values of oil content are given in Table I, along with the standard deviation.

It may be seen from Table I that oil content is highest in the case of *G. hirsutum* and lowest in the case of *G. barbadense* varieties.

Protein in Kernels

The species-wise and combined ranges and average values

TABLE I

Percentage of Oil in Cottonseed Kernels

Item	*Gossypium arboreum*	*Gossypium herbaceum*	*Gossypium hirsutum*	*Gossypium barbadense*	Combined
Number of samples tested	30	11	46	10	97
Lowest value	29.9	26.7	27.9	25.5	25.5
Highest value	35.3	35.3	37.9	34.4	37.9
Mean	32.2	31.3	33.3	28.8	32.3
Standard deviation	1.6761	2.241	2.151	3.063	2.503

TABLE II

Percentage of Protein in Cottonseed Kernels

Item	*Gossypium arboreum*	*Gossypium herbaceum*	*Gossypium hirsutum*	*Gossypium barbadense*	Combined
Number of samples tested	30	11	46	10	97
Lowest value	28.5	30.8	30.3	32.0	28.5
Highest value	38.1	37.9	42.8	41.1	42.8
Mean	34.0	34.5	36.2	36.2	35.3
Standard deviation	2.293	2.318	2.918	2.472	2.794

TABLE III

Free Gossypol Percent in Cottonseed Kernels

Item	*Gossypium arboreum*	*Gossypium herbaceum*	*Gossypium hirsutum*	*Gossypium barbadense*	Combined
Number of samples tested	30	11	46	10	97
Lowest value	0.57	0.82	0.59	1.22	0.57
Highest value	2.38	1.96	2.35	2.41	2.41
Mean	1.27	1.44	1.32	1.72	1.36
Standard deviation	0.374	0.356	0.348	0.416	0.382

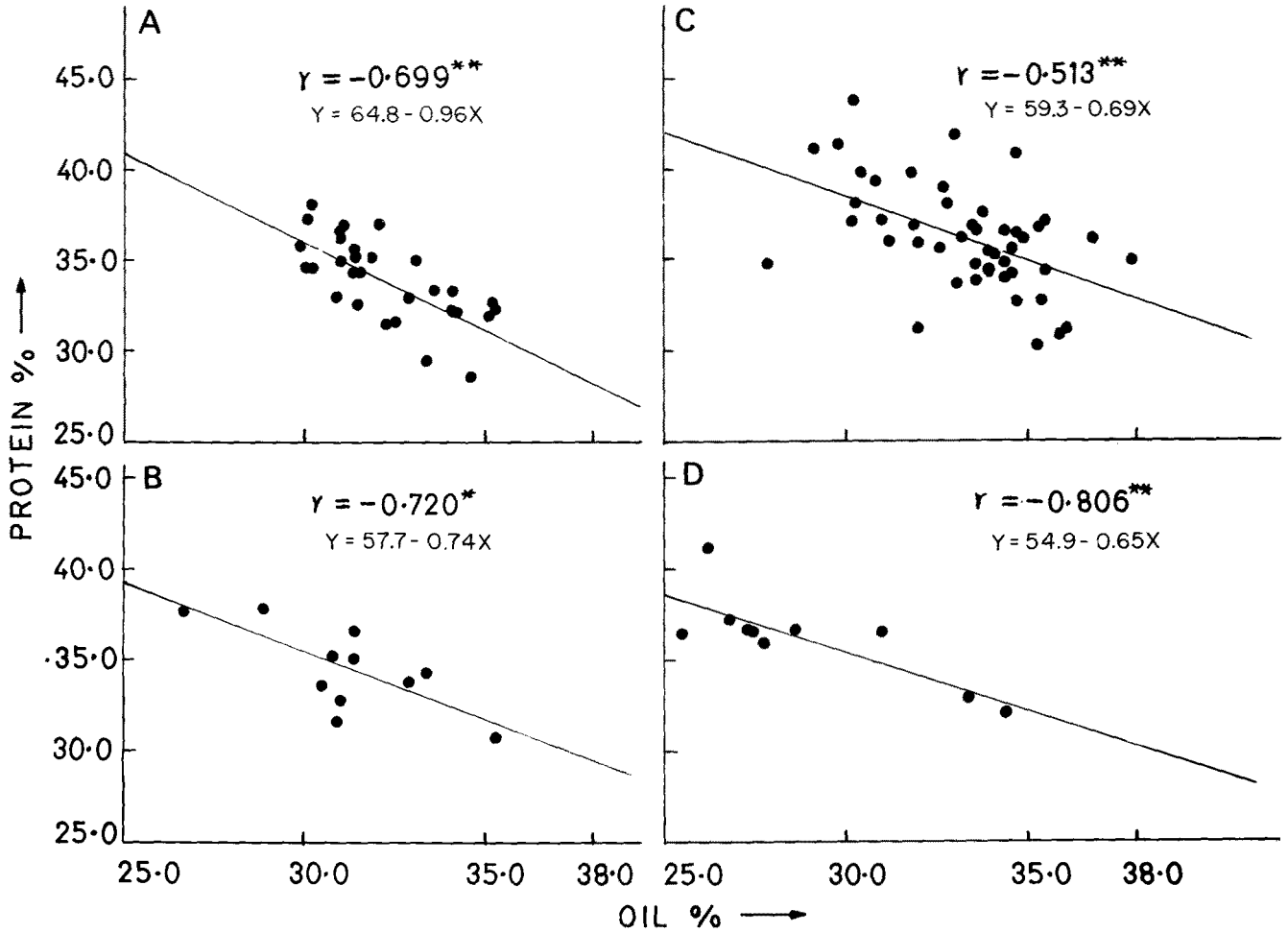

FIG. 1. Relation between protein and oil in cottonseed kernels. A. *Gossypium arboreum*, B. *Gossypium herbaceum*, C. *Gossypium hirsutum*, and D. *Gossypium barbadense* species. r = Correlation, x = oil, y = protein, * = significant at 5% level, and ** = significant at 1% level.

of protein (N x 6.25) content, along with the standard deviation, are given in Table II.

The average protein contents of *G. arboreum* and *G. herbaceum* varieties were almost the same and were lower than those of *G. hirsutum* and *G. barbadense* varieties, which, in turn, had the same mean value (Table III). Protein content was found to have a wider variation in *G. hirsutum* species compared to others.

Free Gossypol in Kernels

The species-wise and combined ranges and mean values of gossypol content are reported in Table III.

Seeds of *G. barbadense* species showed slightly higher percent of gossypol than those of the other three species.

RELATIONSHIP BETWEEN OIL, PROTEIN, AND GOSSYPOL

Relationship between Protein and Oil

It has been observed that protein and oil content of cottonseed are influenced by variety, agronomic conditions, and environment (5,7,9). Relationship between protein and oil in cottonseed kernels of *G. arboreum* species is shown in Figure 1A. The two properties are negatively correlated, and γ is significant at 1% level. Similar correlation between the two properties is observed in the case of *G. herbaceum* species (Fig. 1B), where γ is significant at 5% level. The γ between protein and oil for *G. hirsutum* varieties (Fig. 1C) was found to be significant at 1% level. The two properties also showed a similar relationship in the case of *G. barbadense* species (Fig. 1D), and γ was significant at 1% level. From these data, it is seen that protein and oil in cottonseed kernels of different botanical species are negatively correlated, and the level of significance differs depending upon the species. Correlation coefficient between protein and oil for all the four species combined was -0.434, which is significant at 1% level. These data reveal that any increase in oil content in cottonseed will result in a relative reduction in protein or vice versa. Similar correlations between nitrogen and oil in cottonseed kernels of American cottons

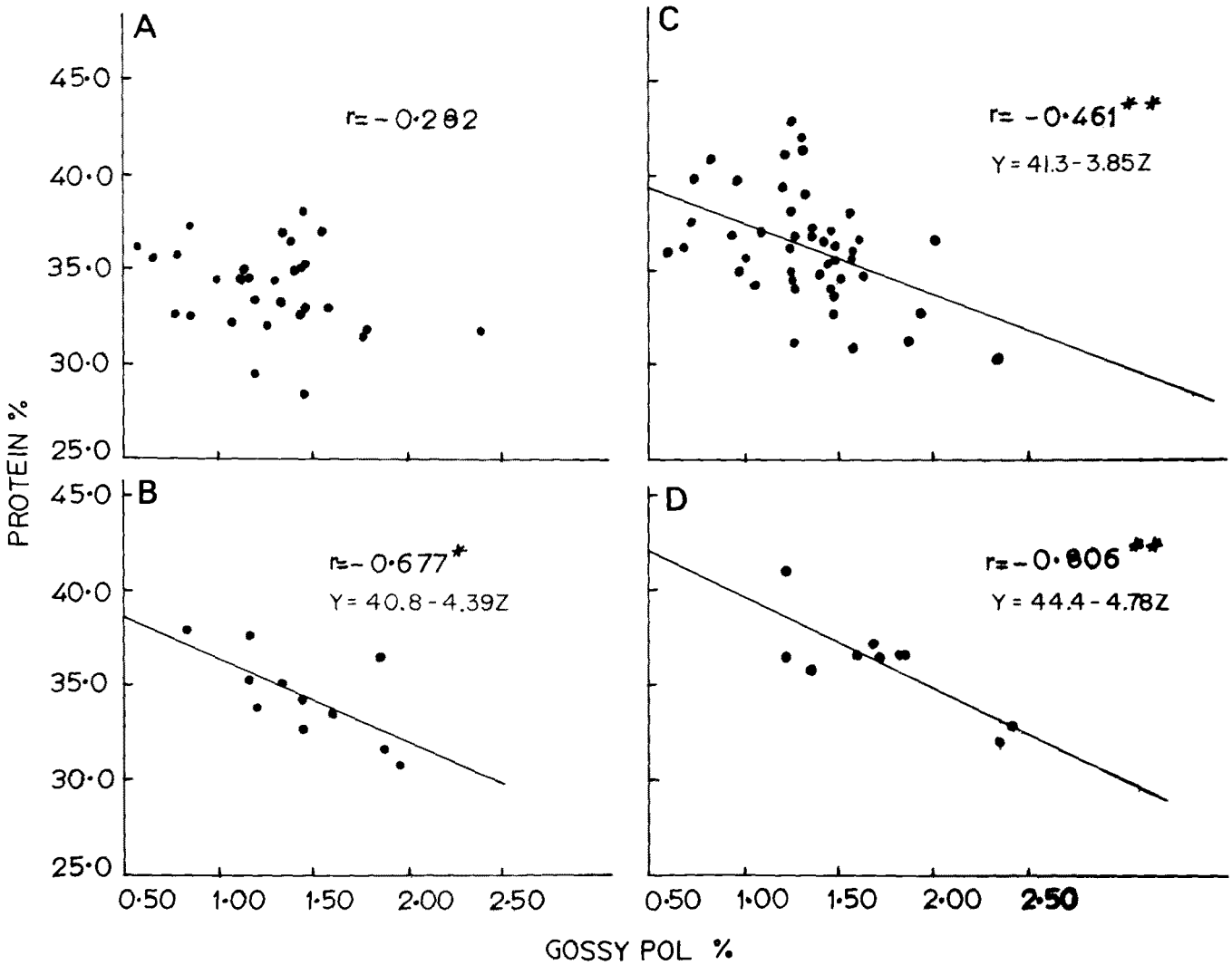

FIG. 2. Relation between protein and gossypol in cottonseed kernels. A. *Gossypium arboreum*, B. *Gossypium herbaceum*, C. *Gossypium hirsutum*, and D. *Gossypium barbadense* species. y = Protein, z = free gossypol, * = significant at 5% level, and ** = significant at 1% level.

were reported by Tharp (5) and Stansbury, et al. (9).

Relationship between Protein and Gossypol

Correlation coefficient between protein and gossypol in cottonseed kernels of *G. arboreum* species was nonsignificant. Figure 2A shows the scatter of values. Protein and free gossypol in *G. herbaceum* species were negatively correlated, γ being significant at 5% level. Regression line and regression equation are shown in Figure 2B. In the case of *G. hirsutum* (Fig. 2C) and *G. barbadense* (Fig. 2D) varieties, the two properties are negatively correlated, γ being significant at 1% level.

From the above, it may be concluded that, in the case of *G. herbaceum*, *G. hirsutum*, and *G. barbadense* species, any reduction in the amount of gossypol will result in an increase in seed protein. Correlation coefficient between protein and gossypol for all varieties combined was -0.355 which is significant at 1% level. Although no significant correlation was found between protein and gossypol content in *arboreum* varieties, the correlation was negative, showing a similar trend as observed in the case of other species. In a similar study on 8 commercial varieties of cotton grown in 13 locations during 3 years, Stansbury, et al., (9) reported significant negative correlation between gossypol and nitrogen in the kernel of each variety.

Relationship between Oil and Free Gossypol

The γ between oil and gossypol was positive and significant at 5% level in case of *G. barbadense* species, while it was nonsignificant in case of other species. Partial correlation between the two constituents for *G. barbadense* varieties was calculated eliminating the effect of protein. The partial correlation coefficient (-.0303) was not significant. That is to say that there is no real correlation between oil and free gossypol in all the four species studied, which means that any improvement in oil content of cottonseed will not result in a similar increase in gossypol content. These findings will be important to cotton breeders interested in increasing the oil content of cottonseeds.

ACKNOWLEDGMENT

Cotton breeders and cotton specialists supplied the cottonseed samples for this study.

REFERENCES

1. Pandey, S.N., N. Thejappa, and V. Sundaram, AICOSCA Newsletter 2:24 (1974).
2. Murti, K.S. and B.A. Rao, "Studies on the Compositional and Varietal Characteristics of Indian Cottonseed during the Decennium 1951-1960," Indian Oilseeds Committee, Hyderabad, India (1963).
3. Carter, F.L., A.E. Castillo, V.L. Frampton, and T. Kerr, Phytochemistry 5:1103 (1966).
4. Frampton, V.L., W.A. Pons, Jr., and T. Kerr, Econ. Bot. 14:197 (1960).
5. Tharp, W.H., "Cottonseed and Cottonseed Products, Their

Chemistry and Chemical Technology," Edited by A.E. Bailey, Interscience, New York, N.Y., p. 134 (1948).
6. Ahmed S., E.-N., J.G. Simmons, and V.L. Frampton, Phytochemistry 8:1949 (1969).
7. Pandey, S.N., and N. Thejappa, Mysore J. Agri. Sci. 9:34 (1975).
8. AOCS, "Official and Tentative Methods of the American Oil Chemists' Society," Third edition, (revised to 1972), AOCS, Champaign, Ill., Methods Ba-3-38, Ba-4-38, and Ba-7-58.
9. Stansbury, M.F., W.A. Pons, Jr., and C.T. Dan Hartong, JAOCS 33:282 (1956).

[Received September 3, 1974]