Improving Indian Tobacco

CJ Kuncheria

In 1914, the Madras government convened a meeting with some of the presidency's tobacco manufacturers as part of an Agricultural and Trade Conference. The hour-long meeting steered itself to discussing the improvement of indigenous tobaccos: manures, soil, and the capability of the ryot to grow and cure better leaf. There was one significant intervention, though, which was reported thus: "Practically no work yet has been done in the country on the improvement of tobacco by seed selection. The firms were of the opinion that this might offer good prospects of evolving improved strains."[1]

The idea that tobacco could be improved by breeding was a novel one. In line with the conference's observation, there is little in prior or contemporary accounts of tobacco schemes in India in this regard. Even in the United States, the leading tobacco growing country, breeding as a way of improving tobacco was a recent development: a 1907 US Department of Agriculture bulletin on the subject introduced itself by trying to convince growers that it could actually improve the crop and that too at no additional cost.[2] However, perhaps unbeknownst to the Madras delegates, such experiments were into their seventh year at the Agricultural Research Institute in Pusa, the premier centre for crop sciences in India. By the time of the conference, scientists there had already applied principles of seed selection and breeding to isolate an improved indigenous variety of tobacco, which had met with approval of the local cigarette factory.

1 *Agriculture and Trade Conference, Madras, December 1914* (Madras: Superintendent, Government Press, 1915), 140.

2 A. D Shamel and W. W Cobey, *Tobacco Breeding*, US Department of Agriculture Bureau of Plant Industry, Bulletin No 96 (Washington: Government Printing Office, 1907).

If the tobacco improvement schemes in India of the nineteenth century were marked by questions of climate, soil, and acclimatisation, into the twentieth century, developments in botany and agricultural sciences opened up the possibilities of rapidly improving crops by scientific breeding. Farmers world over had for centuries had practiced some form of seed selection, watching out for and carefully gathering seed or other breeding material from particularly promising plants. In Europe and the United States, professional breeders in the eighteenth and nineteenth centuries tried to short-cut this natural and slow process of improving crops. The fullest possibilities of using breeding to produce tailor-made crops though came about by the turn of the century 'rediscovery' and deployment of Mendelism: the principles of inheritance of characters which held the promise of rapidly breeding plants that had combinations of desired characteristics. In Britain, the University of Cambridge became the centre for such research.

In India, the early twentieth century reorganisation of the agricultural departments under Curzon following devastating famines saw several Cambridge trained men (and one woman) staff the emerging agricultural scientific establishment in India. This included the two scientists who undertook pioneering research on tobacco, Albert and Gabrielle Howard, the First and Second Imperial Botanists respectively. Under them, the direction of tobacco research at Pusa was set on developing an improved tobacco by selection and breeding practices, including hybridisation. And while breeding practices were not the sole arena for tobacco improvement in Pusa or the rest of the country, they formed the cornerstone of such efforts, and fed into other lines of work such as developing ways of processing the harvested tobacco for use in the emerging cigarette industry.

This essay investigates this new turn in tobacco science, as practised in the scientific institutes of Pusa and other experimental farms, as well as its relationship with conditions and practices of cultivation, and with other actors in the tobacco economy.

Scholars who have studied breeding, Mendelism, and the development of hybrids have shown how the acceptance of these new forms of crop improvement were highly dependent on the nature of institutions in each country and by the existing traditions and prior knowledge about breeding.[3] They have shown that the establishment of Mendelism in universities and agricultural research institutions, when it happened, had more to do with such reasons than due to the ability of the new science to outdo older forms of crop improvement. These studies are invariably from Europe and the United States, and there has been no similar work for nonwestern contexts. For India, for instance, historical research into scientific plant breeding usually focuses on the Green Revolution onwards. This is despite the fact that Mendelism took root in India almost at the same time as it was rising in prestige in Britain, and breeding experiments drawing from Mendelian principles were conducted on a range of crops, such as wheat, cotton, and tobacco from 1905 onwards. A fuller history of Mendelism in India is beyond the scope of this essay, but the discussion on tobacco breeding experiments here may be able to throw some light on Mendelism's Indian career.

What follows is a study of tobacco science in the twentieth century, influenced by these new tools for improving plants and aimed towards producing a crop more suited to the changing requirements of the tobacco industry in India and in the UK. If the aim of improvement in the nineteenth century was to produce a high quality cigar leaf in India that could match the kinds imported from the East Indies, the new ambition was to grow a cigarette tobacco, either for the local factories that begun production from the first decade onwards, or for export to Britain that had become a promising destination due to Imperial Preference — which granting colonial tobacco a lower rate of customs duty — and the rising demand for cigarettes. Both import substitution and export promotion necessitated the requirement of lighter coloured tobaccos shorn of the unpleasant tastes that European observers found in Indian leaf. Breeding

3 I will elaborate on these remarks in a later section, along with full references.

techniques, either by identifying, isolating, and producing ‘pure lines’ of promising indigenous varieties of tobacco, or by hybridising Indian and exotic tobaccos, offered new ways to grow such tobaccos, and Pusa was engaged in such endeavours. But lightness was not merely a property that came from within; as growers and scientists realised the conditions in which the plant grew and the ways in which the leaf was cured were crucial in producing the colour that was much desired.

This essay engages with these considerations by focusing on three key moments. First, I look at the experiments at Pusa to classify and breed the so-called ‘pure lines’ of Indian tobaccos — varietals that had been bred in order that their characteristics remained true across multiple generations. These experiments were conducted as a preliminary to hybridisation as well as to identify economically promising varieties. Second, I look at the development of a hybrid tobacco at Pusa, aimed at blending into one varietal the flavour and colour characteristics of American tobacco and the ‘hardiness’ of an Indian tobacco. Finally, I consider the tobacco varietal that eventually became the dominant one grown for cigarette manufacturing for this thesis’ period of study. This varietal was not a product of these experiments but rather, an exotic varietal. These three moments will demonstrate both the promise as well as the problems of the new improvement programme, and the interplay between the various agendas at work and the market and ecological conditions under which they operated.

Before entering the discussion on how Indian tobacco fared under the new regime of improvement, it is useful to note the background to these developments. In 1880, one of the few Indian officials trained in agriculture had made a cutting remark about the government’s attitude towards improving the land: “a knowledge of Greek plays is deemed a more necessary

qualification than a knowledge of the principles of agriculture."[4] He was no doubt referring to the average heaven-born of the Indian Civil Service. The late Victorian famines in India led to calls for agriculture to be more properly governed; and the Famine Commission recommended dedicated departments of agriculture at the imperial and the provincial levels. These were established from 1881 onwards. The Commission had suggested three roles for the departments: agricultural enquiry, improvement, and famine relief. Into the turn to the century, though, the Indian agricultural department had focused more on the first objective, and its working was more towards improving the country's land records than reforming agriculture itself. In 1889, in response to demands for using scientific means to improve agriculture, the Secretary of State appointed the agricultural chemist John Voelcker to produce a report. This report, published in 1893 among other things, recommended the greater infusion of scientifically trained staff to the departments of agriculture, both at the imperial and the provincial level.

This call for science in the service of Indian agriculture got a boost under Curzon, and the demand for trained staff was met by new graduates from English universities trained in the new botany and the emerging discipline of agriculture. The famine of 1899-1900 led him to shake up the imperial and provincial agricultural departments and strengthening the scientific basis of agricultural improvement. An Inspector General of Agriculture was named to head the hierarchy and provincial departments were given grants to hire trained staff and augment agricultural colleges. Curzon's most momentous initiative was the establishment of the Agricultural Research Institute at Pusa to centralise agricultural research in the country. Funded from a donation of 30,000 pounds from the American philanthropist Henry Phipps, the institute would be the site for modern agricultural science to be practiced in and diffused from in India.

4 WR Robertson, "Agriculture in the Madras Presidency," *Journal of the Royal Society of Arts* XXVIII, no. 1434 (May 14, 1880): 562–76.

Though the founding director was a former indigo planter from Bihar, the institute's key positions was staffed by graduates from British universities. It was here that the pioneering work on tobacco breeding was carried out. It is to the practice of such principles of breeding in the service of improving tobacco that I turn to next.

Tobacco Improvement at Pusa

When the newly constituted Board of Agriculture met for the second time, in 1906 at Pusa, tobacco improvement was listed on the agenda: "[The] object should be to test the possibilities of producing tobacco for European consumption suitable for (1) cigar wrappers, (2) cigar fillers, or (3) pipe and cigarette tobacco.[5] In several ways, the outline of work hewed close to prior schemes, in suggesting cataloguing the existing methods of cultivation and curing, and studies of soil and water. It laid down a division of labour too. Provincial experimental farms were to grow the local tobacco varieties to ascertain the best suited ones, while Pusa would undertake a comparative study. These suggested no break from past traditions of improvement.

The transformation that was to come about in the ways of plant improvement however was foreshadowed by a remark of Albert Howard in a different part of the meeting. Asked about his programme of work, he referred to certain of the proposed cotton experiments, which "were directed to elucidate certain fundamental questions, such as the methods of fertilization of the flower, which it is desirable to investigate further in order to assist detailed work in improvement by hybridization or otherwise."[6] Unlike the cotton improvement experiments of the previous century, which had relied on the introduction of exotic varieties and teaching 'ignorant' ryots better systems of cultivation, the new experiments set out on a new imperative,

5 'Suggestions for a scheme for the improvement of Indian tobacco'. *Proceedings of the Board of Agriculture in India,* 1906. 12

6 'Programme of the Economic Botanist'. *Proceedings of the Board of Agriculture in India,* 1906. 4.

with a focus on selecting and breeding improved varieties.[7] This emphasis would be visible in the experiments with tobacco too. Studies on manuring and the impact of chemicals on tobacco would continue, but the core of Pusa's work on tobacco in the years to come was to isolate 'pure lines' of tobacco, classify them, and understand better the process of how characteristics were inherited over successive generations. This was a preliminary to the task of identifying varieties that had economically significant characteristics, and to attempt crossing varieties and producing hybrids that combined desirable characteristics.

Identifying Tobaccos: The Making of Type 28

Pusa's research into tobacco was conducted largely by Gabrielle Howard and her Indian assistant Kashi Ram. Gabrielle had studied botany at Cambridge and was a fellow there, though unlike Albert, she had not been in the circles which had done the pioneering work on plant genetics; her work was on plant physiology and she had discovered a mechanism of plant photosynthesis that is today named after her mentor, Frederick Blackman.[8] In India, she worked initially as an unpaid assistant to her husband, gathering a CIE for her labours, before being appointed as the Second Imperial Botanist. Biographical details for Kashi Ram are scarce, but he later rose to become assistant to the Imperial Economic Botanist. The Howards and Kashi Ram between them published a series of research papers and bulletins on tobacco improvement, that formed the basis for tobacco science for the period and for the hybridisation work carried out in the 1920s.

---

7 For an account of the experiments on cotton and its failure, see Peter Harnetty, "The Cotton Improvement Program in India 1865-1875," *Agricultural History* 44, no. 4 (October 1970): 379–392.

8 Biographical details about the Howards can be found in Louise E Howard, *Sir Albert Howard in India* (London: Faber, 1953), Accessed at http://journeytoforever.org/farm_library/HI/HItoc.html; Gregory A. Barton, *The Global History of Organic Farming* (Oxford: Oxford University Press, 2018).

The initial labour of Pusa was to collect and classify the varieties of tobacco in India. They would first study the characteristics of tobacco varietals collected from across India, and the amount of variation between them. Second, they would isolate and grow in "pure culture [...] the constant forms obtained" and determine "the best types in cultivation [...] By this means seed of definitely described types is now for the first time available for variety trials and also for hybridization work."[9] Identification and classification were described as a preliminary towards producing hybrids, but the Howards understood the benefits springing from just cultivating these pure lines of seed, to the exclusion of other varietals in the field. For one, the farmer could choose seeds from plants that had a higher yield, or other desirable characters, and thus be more sure of the output from the field. But there was a second consideration, springing from the requirements of uniformity in the crop. A uniform crop would be more in synch with the workflow between the field and the factory that transformed the plant into an industrial raw material. As Gabrielle explained:

> Perhaps, no other factor in the production of high grade tobacco is so important as uniformity in the crop both as regards growth, and also as regards the type of plant grown. Unless the crop ripens uniformly, the difficulties of harvesting and curing are increased while a crop made up of several types of plant, differing in the size, venation, shape and texture of the leaves, increases the cost of sorting out the various grades for

9 Albert Howard and Gabrielle L.C. Howard, "Studies in Indian Tobaccos, No 1. The Types of Nicotiana Rustica, L," *Memoirs of the Department of Agriculture in India (Botanical Series)* III, no. 1 (March 1910): 2; Gabrielle L.C. Howard, "Studies in Indian Tobaccos, No 2. The Types of Nicotiana Tabacum, L," *Memoirs of the Department of Agriculture in India (Botanical Series)* III, no. 1 (March 1910): 60.

market. The maintenance of the uniformity of any desirable type of tobacco is therefore a matter of prime importance.[10]

An added benefit of this uniformity was that it would help the cultivators finish the harvesting process within the narrow window of ideal climatic conditions in Bihar. As the Pusa experience of Begg Sutherland, a firm that had attempted commercial tobacco cultivation in the late nineteenth century, had revealed, the crop had to ripen before the cold set in in January, and be cured before March, when the hot dry winds impaired the process. If the crop did not mature at the same time, the tobacco leaves of varying degrees of ripeness would cure unevenly, making the final produce lose value.[11] Uniformity had to be made natural to the crop, ahead of it being nurtured through improved cultivation practices.

The Howards completed the first two of their objectives by 1910, after three years of work. From the various varieties of *N. tabacum* and *N.rustica* tobaccos collected at Pusa, they cultivated two generations of self-fertilised plants. Selecting from this generation, they grew two further generations of plants in "pure culture", reaching a point where the characteristics of the variety were fixed. That is, they now represented varietals which, if self-fertilised, would produce seeds that would yield plants with the same characteristics generation after generation. In their reckoning, there were 20 varieties of rustica tobacco and 51 of tabacum. Yet, the Howards themselves admitted to the arbitrariness of this categorisation. As they described it, Indian tobaccos lay in "a series", one variety shading into another.[12] The distinctions between

10 Gabrielle L.C. Howard, "Studies in Indian Tobaccos, No 2. The Types of Nicotiana tabacum, L," Memoirs of the Department of Agriculture in India (Botanical Series) III, no. 1 (March 1910): 61.

11 The reason for this particular form of harvesting was that in Bihar's hot weather, priming, the practice of picking individual leaves as they came to maturity, would end up spoiling the leaves as they were stored in advance of the curing process. Priming was practiced in the United States for valuable tobacco, but it was not universal, though it would become so for flue cured tobacco.

12 Howard and Howard, "Studies in Indian Tobaccos, No 1. The Types of Nicotiana Rustica, L," 3–4.

varieties were often slight, making it difficult to ascertain whether they were due to differences of kind, or caused by conditions under which they were cultivated. But the proof of their variance was the fact that these differences were "wonderfully constant, persisting from year to year."[13]

In producing this classification, the Howards made two distinct choices. For the economically unimportant rustica, they decided to typify the plants according to the habit – the general appearance of the plant – and the nature of the inflorescence – the bunch of buds and flowers at the apex of the plant.[14] For tabacum, which formed the bulk of the traded variety, Gabrielle had a greater dilemma, for the serial nature of Indian tobaccos was more pronounced here.[15] From several possible ways of classification, she chose to broadly classify the types based on the nature of the leaf, subdividing each class along the plant's habit. These choices were made for their economic implications.[16] In describing variations in her specimens, Gabrielle invited readers to consider them "in order of economic importance".[17] Botanical characteristics were translated into economical inputs: short plants with closely spaced internodes – the distance between two leaves along the stem – would have leaves in contact with soil, and the dirt would reduce the value of the tobacco produced. Too tall plants would tend to have winds tear the leaves, again diminishing their value. As for the next consideration for classification: "The economic importance of the size and number of the leaves is obvious." In describing the leaves, she pointed out further markers of value. If the angle between the main

13 Howard, "Studies in Indian Tobaccos, No 2. The Types of Nicotiana Tabacum, L," 67.

14 Howard and Howard, "Studies in Indian Tobaccos, No 1. The Types of Nicotiana Rustica, L," 17–18.

15 Howard, "Studies in Indian Tobaccos, No 2. The Types of Nicotiana Tabacum, L," 78.

16 Though this was only implied in the 1910 papers, Gabrielle made this clear in a subsequent paper: Gabrielle L.C. Howard, "Studies in Indian Tobaccos, No 3. The Inheritance of Characters in Nicotiana Tabacum, L," *Memoirs of the Department of Agriculture in India (Botanical Series)* VI, no. 3 (July 1913): 28.

17 Howard, "Studies in Indian Tobaccos, No 2. The Types of Nicotiana Tabacum, L," 68.

rib and the secondary veins was too acute, the leaf would be useless for cigar wrappers. On similar lines, the thickness, the smoothness, the colour, and the texture of the leaf mattered too.

The economic rationale behind the scheme of classification was further made clear by Gabrielle's notes on the various tobaccos, which were placed in classes that reflected their economic potential. Describing a class of narrow-leaved, dwarf plants, she remarked that "it seems probable that the economic value of the tobaccos in this class is not very high." Of a subclass that comprised thick-leaved tobaccos, "They are of no value except for the manufacture of snuff." And finally, the most promising: "This class contains the types which will probably prove the most valuable. The leaves are broad, large and the midribs are not so pronounced as in class A. The distinctive feature is the shape of the leaves which is broad throughout and only slightly narrowed for a very short distance above the base."

The Pusa classification, thus, rather than record botanical truths, were an economic valuation of the various kinds of available Indian tobaccos. It demonstrates Barbara Hahn's insights about tobacco types: that far from being expressions of botanical, or genetic, variation, they are "are a form of market regulation. Varieties represent the classification schemes within which quality can be judged. They embody categories that frame economic decisions".[18] Hahn has shown how the various tobacco types in the United States were historically produced categories, that emerged out of marketing regulations and practices that bound buyers and sellers.[19] Those types reflected congealed marketing relations. The 51 Indian tabacum varieties Gabrielle identified represented an attempt to enter into a network of marketing relations.

18 Barbara Hahn, "Paradox of Precision: Bright Tobacco as Technology Transfer, 1880-1937," *Agricultural History* 82, no. 2 (April 1, 2008): 232.

19 See Barbara M. Hahn, *Making Tobacco Bright: Creating an American Commodity, 1617-1937* (Baltimore: JHU Press, 2011) especially chapter 6, where she discusses how types came into being in the United States and how they had little to do with genetic differences.

Of the 51 varieties, however, the chosen one was not from among the categories that had shown early promise. Nor did it emerge from amongst the American seeds grown under careful husbandry at Pusa: these varieties grew slower than the local varieties and thus were ruled out by the seasonal constraints in Bihar. The best cured tobacco, according to reports from BAT's tobacco factory in Monghyr, came from Type 28, a south Bihar variety. Ground-cured Type 28, the company reported, had "Colour bright and texture above the average of Indian Tobacco with regard to small stems and fibre. We think this particular type of tobacco will make a very fair smoke as a cigarette."[20] In 1913, Albert reported that the entire cured crop produced at a former indigo estate for that season had been taken by ILTDC.[21] BAT began distributing the seed to the Bihar peasantry to grow for its Monghyr factory. In 1918, seed for 4,000 acres was distributed in all, this rose to 12,000 acres in 1920.[22] ILTDC would "give out the seed to anyone who applies for it."[23] The adoption of Type 28 owed to the fact that the seed losses were low, and the transplanted seedlings grew uniform and hardy. This uniformity cut down the harvest time from the usual four to six weeks.[24] Equally importantly, local buyers too had no qualms against the produce, contrary to Albert's early concerns that the lack of competition to purchase the leaf would give ILTDC an advantage over the grower in setting prices. Type 28 would not be confined to Bihar.. The company grew some of the seeds in its farm in Guntur in the Madras presidency and reported that the not only did it grow well there,

20 Letter from RC Harrison, ILTDC, 12 April 1912. Cited in Albert Howard and Gabrielle L.C. Howard, "The Improvement of Tobacco Cultivation in Bihar," Bulletin of the Agricultural Research Institute, Pusa (No 50, 1915), 17.

21 *Report of the Agricultural Research Institute and College, Pusa.* 1912-13, 36.

22 *Report of the Agricultural Research Institute and College, Pusa.*1917-18, 47; 1919-20, 52.

23 *Report of the Agricultural Research Institute and College, Pusa.* 1917-18, 48

24 Letter from Acree, ILTDC. Cited in *Report of the Agricultural Research Institute and College, Pusa, 1917-18*, 48.

the cured leaf had a good colour too.[25] This lead to a jump in the quantities of seed distributed by Pusa to that enough for 50,000 acres in 1921, rising to around 90,000 acres in 1923.[26]

Hybridising Tobacco

Type 28 was Pusa's first success in tobacco, but its popularity was short lived. By 1923, changes in the tobacco demanded by cigarette manufacturers hit the expansion of the variety. Frederick Shaw, Albert's successor as the Imperial Economic Botanist, pegged this to that "the change in the public taste".[27] Around the same time, the Madras government's Guntur agricultural station too reported that "it is said that the Pusa variety has a bitter taste," though the reporting official put its "lovely yellowish brown colour" ahead of that produced by locally-grown varieties from seed imported from the United States.[28]

Both of these accounts suggest a change in the smoking public, at least those to whom these products were marketed. There is some supporting evidence for this from accounts of officials monitoring the trade, who had noted a surge in the imports of cheap cigarettes of American origin in the immediate aftermath of the first world war. American officials attributed the increased imports to changing tastes, including those of returning soldiers who had smoked the article in Europe.[29] It is quite likely that the expansion of the market through cheap American

25 Letter from Acree, ILTDC. Cited in *Report of the Agricultural Research Institute and College, Pusa, 1920-21,* 14

26 *Report of the Agricultural Research Institute and College, Pusa, 1920-21,* 14*; Scientific Reports Of The Agricultural Research Institute, 1922-23*, 17. The latter figure is my calculation, using an approximation 1 ser of seed could be sown over 150 acres.

27 *Scientific Reports Of The Agricultural Research Institute.* 1924-25, 16

28 *Report on the work done on the Guntur Farm.* 1922-23. Department of Agriculture, Madras. IOR V/24/1481. BL.

29 'Tobacco', Calcutta, 15 June 1922. USNA FAS Narrative Reports (1904-1939) Great Britain (India) Tariffs-Wool; 1919-1938 Tobacco. Record Group 166.

tobacco filled cigarettes, shifted consumer preferences away from cigarettes using Indian leaf. While this cannot be directly demonstrated, it is strongly suggested by the increasing imports of American tobacco in the early 1920s. British American Tobacco's (BAT) cigarette factory in Monghyr, which had previously used only local tobacco, began blending American leaf in its offerings.[30] The Indian Leaf Tobacco Development Company, BAT's purchasing arm in the subcontinent, from around this time began experimenting with growing American varietals in Guntur, moving away from buying the local varieties of tobacco. Pusa scientists, in response, returned to the drawing board, this time to develop a hybrid that could meet the new demand from cigarette factories. As Shaw put it:

> The problem with which the cigarette making industry in India is at present confronted is to obtain a type of tobacco which will resemble American tobaccos in flavour, colour and smoking qualities, while possessing the hardiness and growing qualities of the best Indian varieties.[31]

Shaw's ideal tobacco had been in the making for a decade at Pusa. Following her work on classification, Gabrielle Howard had jumped onto the question of developing a cigarette tobacco suited for Bihar. As she saw it, the local varieties were inadequate to the task and "It will be necessary to build up, by hybridization, new kinds of tobacco, suited to Indian conditions of growth, which possess in addition the qualities necessary to obtain a better price."[32] This could be achieved by mating together American tobaccos which "maintain their good texture and flavour, the chief points in which the Indian tobaccos are deficient", with a local variety "which is robust and possesses a suitable habit of growth."

30 Note by GL Corbett, 31 Jan 1924. NAI Central Board of Revenue, July 1924 Customs Duties C, No 82. NAI

31 *Scientific Reports Of The Agricultural Research Institute.* 1924-25, 15

32 Howard, "Studies in Indian Tobaccos, No 3. The Inheritance of Characters in Nicotiana Tabacum, L," 28.

Here, though, she was on uncharted territory. There had been no attempts to develop a hybrid tobacco anywhere and little was known about how characters manufactures prized were inherited over generations. As late as 1936, the USDA echoed her: "these elements in the quality of tobacco are extraordinarily subtle. Not only can they not be measured as yet; by the same token, they are not under the control of the plant breeder. Since he has no notion what factors are responsible for these qualities lie cannot breed for them."[33] To add to her difficulties, as her experiments proceeded, Gabrielle discovered the high sensitivity of the plant to minute changes in the surroundings. Even the slightest difference in the uniformity of the land, or of available sunlight, produced drastic differences in the plant. Very little emerged of practical utility emerged out of her experiments, though she noted as important the fact that the most promising hybrid for further experiments was a product of two "useless forms".[34]

The actual task of developing a hybrid fell into the hands of Gabrielle's erstwhile collaborator, Kashi Ram. As he began his experiments, a second shift had been visible in the kind of tobacco required by cigarette manufacturers. This was occasioned by the introduction of flue curing in Guntur by ILTDC, to produce a bright coloured leaf, mostly for export, but also to feed BAT's factories in India. Flue curing had just begun, but the increasing salience of colour as a mark of quality meant that it was taking steps to replace the older air curing that was practiced in Guntur. This meant that any improved cigarette tobacco emerging from Pusa had to also take into consideration this new form of processing.

Here Type 28 failed, and it seemed that the only varieties that successfully produced the required colour were those grown from imported American seed. The problem was, however, that the American varieties grew slower, and thus in Bihar, required to be transplanted earlier

33 USDA Yearbook of Agriculture, 1936

34 Howard, "Studies in Indian Tobaccos, No 3. The Inheritance of Characters in Nicotiana Tabacum, L," 106, 69.

than the local varieties. Pushing this leg of cultivation backwards meant that it would coincide with the last of the rains, and heighten the incidence of leaf spot disease, brought about by a fungus that thrived in moist weather. In addition, the rains added to the losses of seedlings in the bed, necessitating replacement sowings and thus disturbing the requirement for uniformity in the transplanted crop. Kashi Ram thus embarked upon a series of experiments to cross Type 28 with Adcock, an American variety that had been introduced into Guntur by ILTDC, and which in Pusa's experiments, was judged the most promising of exotics.

As in Gabrielle's work on classification and on inheritance, Kashi Ram's hybridisation experiments too zigzagged between botanical type and economically desirable kinds, between the pure science of establishing how characters were transmitted and the more practical task of producing a cigarette tobacco. Thus, out of the first generation of crosses, he chose for breeding the second generation parents whose for "their economic qualities than as types with definite and clear cut contrasting characters which would afford an easy study of the problems of inheritance."[35] The characters chosen for study were the time to flowering, the height of the plant, the number of leaves, and the broadness of the leaf, all important ingredients of a high yielding cigarette leaf that matured within the short growing window in Bihar. Of the 4,000 second-generation plants grown, 200 were selected as promising. Some promising hybrids were isolated – at least three, H 142, H 156, and H 177 found some favour.[36] That such tobacco could be potentially be produced in India gave ILTDC confidence to expand its network of flue-curing barns. "Your hybrids are splendid and the results you have obtained in obtaining bright lemon coloured leaf from Flue Curing barns, have strengthened our courage to the extent

35 Kashi Ram, "Studies in Indian Tobaccos, No 6. The Improvement of Indian Tobacco by Hybridization," *Indian Journal of Agricultural Science* I, no. IV (August 1931): 460.

36 Ram, "Studies in Indian Tobaccos, No 6. The Improvement of Indian Tobacco by Hybridization" See also PG Minneman, Tobacco Rpt 169: Tobacco In India, 17Jan 1938. RG 166 FAS Narr Rpts 1920-1940 India Rubber-Wool Box 132 Folder: India tobacco 193. USNA1-1941.

of increasing the number of our barns from two last year to forty this year," an ILTDC official wrote to Shaw, complimenting "the quality and colour of your Hybrid no. 177, which is as promising as any Indian Flue Cured tobacco we have seen."[37]

Company Science in Guntur

Yet, when Adcock was replaced in India as the main leaf used to produce cigarette tobacco, none of these hybrids took its place. Rather, it was another American variety that came to predominate. To understand this transformation, we need to travel south of Pusa, to Guntur, where ILTDC had concentrated its efforts on sourcing tobacco. Here, from initially relying on regular supplies of seed from the United States, the company from the 1930s began to use seed selection and breeding techniques to develop strains more suited to the region.

Guntur, on the south west coast, is an unlikely region for cigarette tobacco to be cultivated. World over, such tobacco is grown on sandy soils, to avoid waterlogging at the roots. Cigarette tobaccos also require the plant to grow with minimal nitrogen uptake, especially in its later growing stages, as the leaves tend to be thicker and coarser with higher nutrition. The soil in Guntur, however, is the black cotton soil of the Deccan, which is heavy clay. What differentiated Guntur cigarette tobacco from other cigarette tobaccos, and for that matter, other tobaccos grown in the region, was that it was grown as a dry crop, with no watering. Rather, cultivation utilised the black soil's capacity to retain moisture from the monsoons, using this to grow the plant in its early stages. As the retained water in the soil declined, the availability of nutrients to the plant reduced, fulfilling the low nitrogen requirement. The resulting tobacco's

[37] ILTDC to Shaw, 28 Feb 1929. India Education, Health and Lands (Agriculture-A) Proceedings, August 1930. Progs nos. 7-8. NAI.

mild flavour and light colour, qualities that marked it superior to other Indian cigarette tobaccos, thus, were products of this suppressed growth. Yet, as a leading textbook says: "There is a price to be paid for coaxing a crop out of such a hostile environment. Yields are consistently low"[38] This was one of the reasons that contemporary reports stressed on the importance of the damp *pairu* sea winds that blew in the winter; when they were feeble the crop tended to be undeveloped.[39] In addition to these peculiar ecological conditions, the comparatively mild weather in February and March allowed air curing to proceed without the difficulties faced in Bihar.[40]

ILTDC had begun its operations in Guntur by sourcing local varieties of tobacco. Once it had established itself in the region and built its own network with growers, the company began supplying American seed to cultivators to grow for BAT's factories in India and for export. The demand for Adcock, whose seeds the company began distributing from around 1923, coincided with the expansion of BAT's cigarette manufacturing in India and the gradual indigenisation of its top brands. Earlier, it had imported brands such as Gold Flake; as a result of the hike in customs duties on manufactured and unmanufactured tobacco, these brands were manufactured in Indian factories using a greater proportion of Indian leaf. From the account of Ethirajulu Naidu, a leading tobacco merchant and politician of Guntur, ILTDC's earlier purchases were for the cheaper brands of cigarettes, the kinds that were in competition with bidis.[41] With the substitution of imported tobacco with Indian, the company entered into

38 B. C. Akehurst, *Tobacco* (London: Longman, 1981), 190.

39 See, for instance, *Report on the work done on the Guntur Farm. 1927-28*. Department of Agriculture, Madras. IOR V/24/1481. BL.

40 *Report on the work done on the Guntur Farm. 1925-26*. Appendix 1. Department of Agriculture, Madras. IOR V/24/1481. BL.

41 Oral evidence of M R Ry Diwan Bahadur PCN Ethirajulu Nayudu Garu, Madras. *Madras Provincial Banking Enquiry Committee Report, 1929-30.* Vol IV: Oral Evidence: 219

contracts with ryots to grow tobacco out of seed it distributed. Not all of this tobacco was flue cured. Air curing was the prime means of processing the crop, and not until the 1930s did flue curing become predominant in the region.

Adcock was the first varietal to be successfully tried. As in Pusa, it performed best of all the varietals tried out. But it had its drawbacks. "[T]he leaf will assume a red colour after a heavy damp night, on air curing racks," was the experience of R. Swainson-Hill, ILTDC's chief botanist and chemist.[42] Describing another lot, Swainson-Hill noted that a bale of freshly cured Guntur leaf had the colour of "a good Bright Virginia", but within a week, "the nice bright colour changes to a much darker dead looking leaf (B) almost a light shade of Dark Virginia."[43] In contrast, he wrote, there was a new variety he had been trying, which "appears to resist this peculiarity, and does not so far depart from the usual nice bright leaf". This was a variety called Harrison Special "which produces a most wonderful leaf by air curing, it is what is termed a hundred per cent bright."[44] It was this Harrison Special that became the preferred tobacco in Guntur. In addition to its better colour, this variety was also reported to yield better than Adcock and withstand higher ambient temperatures while growing.[45]

To distribute its seeds, ILTDC had established nurseries in the sandy soils of the coastal areas of Guntur. Here, it grew tobacco seedlings for ryots who grew them under bond for the company. Till around 1928, the distributed seedlings were grown straight from the imported seeds; but from then, the company decided that better results were obtained from first generation seeds, that is, seeds from plants that had been grown in Indian out of the imported

42 Swainson-Hall to Hill, 3 March 1927. Directors' Correspondence Vol 149. 333. Royal Botanical Gardens, Kew (RBGK).

43 Swainson-Hall to Hill, 30 March 1927. Directors' Correspondence Vol 149. 334. RBGK.

44 Swainson-Hall to Hill, 3 March 1927. Directors' Correspondence Vol 149. 333. RBGK.

45 *Agricultural Marketing in India: Report on the Marketing of Tobacco in India and Burma* (New Delhi: Manager of Publications, 1939), 31.

seeds.[46] Both of these practices required annual imports of seeds, for it was believed that that plants from the second generation reverted back to its parental characteristics and lose the properties they were prized for.[47] But the requirement of harvesting first generation seeds necessitated a further round of breeding practices at the company's end, to select for plants that were true to the type. Seedlings from imported seeds were grown under close watch, with supervisors removing all mature plants that did not meet a list of desirable characters.[48] The supervisors were to look for the shape and characteristics of the maturing leaf: it had to be broad, of an even light green colour, a silky texture, and with no prominent veins. The plant itself had to be over 3 feet tall and have at least 10 useful leaves. All other plants were eliminated as rouges. Once the plant had matured, and a final check had been made of its characters, the seed heads were removed for drying, storage, and further distribution to ryots.

From 1937, following a ban on tobacco seed exports from the United States, ILTDC began a set of experiments to produce what it called an acclimatised Harrison's Special.[49] This was a process of growing a plot of self-fertilised Harrison's Special, and eliminating plants that had shown reversions. Plants that displayed the listed desirable characteristics were used for

46 Indian Leaf Tobacco Development Co, *Indian Tobacco Leaves. A Story of Co-Operation in India. [An Account of the Activities of the Indian Leaf Tobacco Development Company.]* (London, 1943), 31.

47 'Seed Production – Leaf District South India.' *Information: A Periodical Summary of Ideas from all Quarters.* 8 March 1949. *Information* was a journal internally circulated within BAT and this account is perhaps the only available account of ILTDC's seed operations in Guntur. It was made public as part of the 1998 Tobacco Master Settlement Agreement between the United States government and tobacco companies. Very few of the BAT documents available are for the pre 1950 period though. Accessed at https://www.industrydocuments.ucsf.edu/docs/sgxg0207

48 'Seed Production – Leaf District South India.'

49 The ban was imposed by a law passed by the United States Congress, over a first presidential veto, and was occasioned by concerns that foreign nations were using American seed to develop a tobacco export trade that threatened American domination of the market.

seed, and the experiment was repeated the following year. A second series of experiment was to develop an early maturing Harrison's Special. Such a variety could be sown later in the season, and avoid being planted during the monsoon season. This was so that the plant could be protected from leaf spot, the same fungal infection that had troubled growers of Adcock in Pusa. Both these experiments took on "paramount importance" around 1941, when ILTDC's stocks of imported seeds neared exhaustion.[50]

From that year on, ILTDC began a form of pedigree breeding, a method that had been used in France by the famed breeder Louis de Vilmorin in the 1850s.[51] This was a method Vilmorin had borrowed from cattle breeders, and aimed at creating a known lineage by repeatedly selecting the best plants from each successive generation, until such time that the line seemed to achieve stability in the required characters. In Guntur, ILTDC practised what it called the 'plant-to-row' method. Here, seedlings originating from each parent plant were grown in rows. The entire row would be eliminated from the next generation of seed propagation if any of the mature plants did not meet the set standard. By 1944, ILTDC made its final selection of both acclimatised Harrison's Special and of an early maturing variety, both of which were used to produce one last generation of experimental plants. Out of this generation, it selected some 500 plants each for the 'Mother Seed', representing the stable genetic material that could be reproduced. In the coming years, all seed given out to ryots would be from self-fertilised progeny of these seeds. By 1948, ILTDC reported that it had been able

50 'Seed Production – Leaf District South India.'

51 On the pedigree breeding method, see Noël Kingsbury, *Hybrid: The History and Science of Plant Breeding* (Chicago: University of Chicago Press, 2009), 124–26; For the role of the Vilmorins in the history of plant breeding, see Jean Gayon and Doris T. Zallen, "The Role of the Vilmorin Company in the Promotion and Diffusion of the Experimental Science of Heredity in France, 1840-1920," *Journal of the History of Biology* 31, no. 2 (1998): 241–62, https://doi.org/10.1023/A:1004335619901.

to not only produce an Indian Harrison's Special, but also a variety that matured 12 days earlier than usual.[52]

Conclusion: An Indian Home for Mendel?

This discussion on the development of an Indian flue-cured tobacco varietal allows us to analyse the introduction of a new plant technology in the subcontinent and evaluate the existing work on tobacco improvement. In a series of publications, Kathinka Sinha-Kerkhoff evaluates the Pusa experiments and the introduction of improved tobacco in Bihar under its programmes. In her words, the project was one of transforming black "desi" tobacco into yellow "vilayati" tobacco.[53] It was a product of a "precarious dependency" among a quadruple of "government, scientists, British private capitalists (including BAT and indigo planters) as well as the Indian tobacco cultivators (including zamindars and other 'cultivators' in Bihar),"[54] Sinha-Kerkhoff's work usefully points out the linkages between the emergence of a tobacco industry and the diffusion of the improved variety of tobacco in Bihar. Yet, its focus on one province, and more fatally, on just the tobacco science produced at Pusa, leads her to a faulty argument on why cigarette tobacco did not embed itself in Bihar. She argues that the failure was due to political unrest in the province, including the boycott of cigarettes during the 1930 Civil Disobedience Movement, and the transfer of the Agricultural Research Institute to Delhi following the great Bihar earthquake of 1934 that destroyed many of the buildings in Pusa. Elsewhere, she points out the role of British control of the sector: "This dependency of Indian tobacco cultivators on

52 'Seed Production – Leaf District South India.'

53 Kathinka Sinha-Kerkhoff, "Yellow Tobacco, Black Tobacco: Indigenous (Desi) Tobacco as an Anti-Commodity," in *Local Subversions of Colonial Cultures: Commodities and Anti-Commodities in Global History* (New York: Palgrave Macmillan, 2016), 33.

54 Kathinka Sinha-Kerkhoff, *Colonising Plants in Bihar (1760-1950): Tobacco Betwixt Indigo and Sugarcane* (Patridge, 2014).

outside 'capital, skill/knowledge and manpower' proved disastrous for the final and permanent embedding of cigarette tobacco in Bihar."[55] This is a puzzling assessment, for, under similar conditions of foreign control and under the exact same company, Guntur became the Indian centre for flue-cured tobacco, and continued to be the major producer for such tobacco into the postcolonial period. Rather, as I have shown, the reasons for Bihar's decline as a cigarette tobacco producer for BAT have to be sought elsewhere. Ecological conditions played their role, with Guntur's soil and weather producing a lighter tobacco than Bihar. As Pusa's own reports itself suggested, Bihar cigarette tobacco hit its peak in 1923; by this time BAT had been in Guntur for over a decade and was embarking upon its own trials of improved tobacco. The political economy undergirded this shift: the ability of ILTDC to enter into contracts and work them to its benefit was greater with the ryots of Guntur than the zamindars of Bihar, many of whom were Europeans who had formerly been indigo planters. But what made this lighter tobacco more valuable to BAT in India than the darker tobacco from Bihar was the shift in consumer preferences and the demands of the export market. With Bihar's tobaccos being rejected and Guntur's tobaccos accepted in the London market, and with the replacement of imported American tobaccos with Indian leaf, ILTDC's focus moved southwards. The changing market, and the eclipsing of Pusa's improvement programme by ILTDC's own, I argue, were responsible for this shift away from Bihar.

More broadly, this account of the quest for an improved Indian tobacco allows us to consider Mendelism and plant breeding in a non-Western context. In the existing scholarship, focusing on the introduction and career of Mendelian breeding in Europe and the United States, the success or failure of this new science has been pegged to the political economy of

55 Kathinka Sinha-Kerkhoff, "Embedding Cigarette Tobacco in Colonial Bihar (India): A Multi-Dimensional Task," in *Embedding Agricultural Commodities: Using Historical Evidence, 1840s–1940s* (Routledge, 2016), 114.

agriculture and to the presence of prior traditions of breeding. In the United States, Mendelism was midwifed by the Department of Agriculture, which promoted the new science through its experimental stations and agricultural colleges.[56] It arrived at a time when agricultural science was becoming professionalised, and conducted by university trained workers who were looking for generalisable ways of understanding inheritance and breeding. In France, on the other hand, Mendelism was resisted, owing to a combination of intellectual traditions that were hostile, as well as due to the weak links in the French academy between biological research and agricultural research.[57]

Of more immediate relevance to the Indian experience is Mendelism's success in Britain. Paolo Palladino has shown that rather than a victory of a better science, the reasons for the establishment and rise of Mendelism had to do with the political economy and the nature of institutions in the country. Palladino notes that the value of Mendelian principles was questioned within the community of agricultural scientists in Britain.[58] He suggests that British plant breeders supported Mendelian research in the academy in order to shift the costs and

56 Diane B. Paul and Barbara A. Kimmelman, "9. Mendel in America: Theory and Practice, 1900-1919," in *The American Development of Biology*, ed. Ronald Rainger, Keith R. Benson, and Jane Maienschein (Philadelphia: University of Pennsylvania Press, 1988), https://doi.org/10.9783/9781512805789-012.

57 Jean Gayon and Richard M Burian, "France in the Era of Mendelism (1900–1930)," *Comptes Rendus de l'Académie Des Sciences - Series III - Sciences de La Vie* 323, no. 12 (December 2000): 1097–1106; French breeders too were cool towards Mendelism. Bonnueil notes the skepticism due to the practical constraints of applying the principles to develop made-to-order hybrids of complex crops like wheat, but lays the reason upon the differing experimental cultures of the breeders and the Mendelians. Unlike the Mendelians who saw the gene as the unit to work with, breeders chose the varieties as the basic unit for manipulation. Christophe Bonneuil, "Mendelism, Plant Breeding and Experimental Cultures: Agriculture and the Development of Genetics in France," *Journal of the History of Biology* 39, no. 2, (2006): 281–308.

58 Paolo Palladino, "Between Craft and Science: Plant Breeding, Mendelian Genetics, and British Universities, 1900-1920," *Technology and Culture* 34, no. 2 (1993): 300–323.

uncertainties of plant breeding onto the state, while Cambridge took on the task in order to draw on state- and private-support that it could piggy back on for pursuing more fundamental questions.[59] Berris Charnley also point out the close personal and professional linkages between the Mendelians, members of learned societies, and officials in charge of disbursing state grants for research.[60] There was thus broad political support for a closely knit group, leading to Mendelians occupying a prominent position in the agricultural landscape of Britain.

Something similar can be said for India and for why breeding became the main line of attack for the improving tobacco. Under Curzon's reforms, several of the positions in Pusa and other institutions of agriculture at the all-India and the provincial levels were staffed by scientifically trained personnel. Several of them were from Cambridge, and had connections with the key figures of Mendelian science. A mediating figure between the Indian hires and the new botany emerging in British universities was William Thiselton-Dyer, the director of the Royal Botanical Gardens at Kew, which long had had a say in the staffing of the British Empire's botanical outposts. Albert Howard was one of them. While he had left Cambridge before the Mendelian turn there, his career suggests close connections with many of the key figures there. James Mollison, the Indian inspector general of agriculture, described Albert as having worked alongside Reginald Biffen, the Cambridge agricultural scientist whose work on hybridising wheat was crucial to the prestige of Mendelism.[61] He was recommended for his

59 Paolo Palladino, "The Political Economy of Applied Research: Plant Breeding in Great Britain, 1910-1940," *Minerva* 28, no. 4 (December 1990): 446–68.

60 Charnley, "Agricultural Science, Plant Breeding and the Emergence of a Mendelian System in Britain, 1880-1930" especially Chapter 1.

61 Mollison to Secretary, India Revenue and Agriculture. 28 March 1907. 219. RBGK MR/102. This is formally correct, for the two were together in the laboratory of their common mentor Marshall Ward for a summer, before Albert left for the West Indies. There is no record of them having collaborating, and is unlikely considering their work that summer was in quite diverse areas.

Indian post by A.D. Hall, the director of the Rothamsted Experimental Station and co-founder with Reginald Biffen and others of the Genetics Society.[62] And finally, Albert's work was published in the very first issue of the Cambridge Mendelians' *Journal of Agricultural Science.*[63] Apart from Howard, four others were listed by Mollison as having studied at Cambridge; but there were others too, including Hugh Martin Leake, then head of the Saharanpur Garden, who later went on to develop hybrid cottons in India.

Nothing quite demonstrates the prestigious position of Mendelian science in India at the turn of the century as this note by Mollison:

> I have personally studied at Cambridge and elsewhere in England all that has been done by Mr. Biffen and other improvers of agricultural crops. We are in touch with similar workers in all parts of the world. The application of Mendel's principle has been followed in India for some years. I cannot, except in great detail, describe the extent of work which has been done in the improvement of agricultural crops in India.[64]

This was certainly an exaggeration.[65] But the statement points to the patronage in India towards Mendelism, which led to this new science being adopted in the country. That the Pusa Institute and much of the Indian government's agricultural science establishment were beginning with a clean slate meant that there was little resistance from older traditions of

62 A.D. Hall, 2 Nov 1904. 202. RGBK MR5/4

63 Albert Howard, "The Influence of Pollination on the Development of the Hop," *The Journal of Agricultural Science* 1, no. 1 (January 1905): 49–58, https://doi.org/10.1017/S0021859600000149.

64 Mollison to Secretary, India Revenue and Agriculture. 28 March 1907. 219. RBGK MR/102

65 Little had been done concretely in terms of improvement at the time of this note. Albert's great success was his work on wheat. Pusa hybrid would be sown widely in India as well as be used in Australia and Britain, but that was in the 1920s. Barton, *The Global History of Organic Farming*, 73–74 Barton's biographical account of Albert rightly points out that these were the forerunners to the Indian Green Revolution hybrids of the 60s. .

improvement. Not that there was much of a past body of work that accumulated: it is remarkable how little of the new improvement programme referred to older projects. For tobacco, for instance, there is little in their papers that the Howards or their collaborators ever seriously engaged with the tobacco improvement attempts of 1870 by Begg Sutherland, conducted on the very same land on which the Pusa institute came up. The closest they came was to denounce older methods of improvement as focusing on developing curing practices rather than cultivation itself.[66]

How much did Mendelian principles contribute to the improvement of Indian tobacco? Exploring this question also allows us to consider the worth of these principles outside the laboratory. We have seen that into the early 1920s, the Bihar factory of BAT was encouraging of Pusa's efforts and relied on Type 28 to expand its sources of raw materials. Yet, as the epicentre of improved Indian tobacco moved southwards to Guntur, and with an increasing focus of BAT in producing superior cigarettes and in exporting tobacco, this reliance seemed to diminish. Whereas ILTDC had into the early 1920s distributed Type 28 among Bihari peasants and even in Guntur, despite its praise of the hybrids, the evidence suggests that it did not use H 177 and other hybrids widely. One reason for this may have been that the hybrids performed poorly in Guntur.[67] While the hybrids were recommended by provincial agricultural officials in Madras, were distributed through the experimental farm in Guntur, and may have been used by some ryots to grow tobacco, its rejection by the biggest buyer in the region sounded a death knell.[68]

66 Howard and Howard, "The Improvement of Tobacco Cultivation in Bihar," 2–3.

67 "[T]his strain was found to have limited adaptbility". *Indian Tobacco; a Monograph.* (Madras: Indian Central Tobacco Committee, 1960), 123.

68 See, for an instance of H 177 being recommended, Ch. V. Saravayya, "The Position of Madras in the Tobacco Industry of India," *The Madras Agricultural Journal* xxii, no. 2 (July 1934): 230–45.

By the 1940s, the Indian government itself had given up on these hybrids. As cigarette seed stocks in India dwindled due to the American embargo and the Second World War, the Imperial Council of Agricultural Research in 1943 got the Madras government to produce an indigenous stock of Harrison's Special, and two other exotic varietals.[69] Further research on improving stock was concentrated on more intensively selecting from the available genetic material of Harrison's Special, resulting in the development of HS 9 at the newly established Central Tobacco Research Institute at Rajamundhry.[70]

The Mendelian promise of rapidly developing hybrids was hardly fulfilled in tobacco. This is unsurprising, if we consider the example of ow its foundational success in Britain: the hybrid wheat. Berris Charnley has shown how Reginald Biffen's own experiments towards producing the Yeoman hybrid resembled pre-Mendelian breeding practices, and in no significant way shortened the time to commercial deployment of the improved variety.[71] Nor, as Biffen and other claimed, did the Mendelian hybrid banish the problem of rouges, plants with undesirable characteristics that emerge as a consequence of accidental mixing of seed, or natural crossbreeding, or mutations.[72]

The Howards' isolation of Type 28 and Kashi Ram's hybrids relied less on Mendelian principles – indeed, Gabrielle had been unable to produce anything resembling useable information on inheritance – and more on the slow process akin to pre-Mendelian breeding. Yet, what distinguishes the case of Indian tobacco is that here, unlike in the West, breeding as

69 *First Annual Report of the Indian Central Tobacco Committe, 1945-1946*, 8.

70 *Indian Tobacco; a Monograph.*, 114 The CTRI did conduct hybridisation trials at a later period, but none of the parents were indigenous varietals. .

71 Berris Charnley, "Agricultural Science, Plant Breeding and the Emergence of a Mendelian System in Britain, 1880-1930" (PhD, University of Leeds, 2011), 154–55.

72 The role of mutations was not understood at that time, leading to Biffen claiming accidental mixing to be the cause.

a method of improvement was brought into a practice, at least in the scientific establishment, through the proponents of Mendelism. ILTDC may have termed its innovations in seed production as acclimatisation, but its practices of growing first generation seeds and of developing the acclimatised Harrison's Special, were both breeding practices that owed their Indian careers to the practices of Mendelians. Thus, while Mendelism itself was a failure for tobacco, and was hardly considered outside the state-backed scientific establishment, its lasting effect was to turn the focus of improvement towards selection, ultimately leading to the varietals that became established in Guntur and elsewhere.