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Level of Agricultural Technology in India (1757–1857)*

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This article seeks to evaluate the various aspects of agricultural techniques and technologies in India during the East India Company rule. This period represents a confrontation between tradition and modernity, as also intellectual intercourse between the West and India. This cultural contact exerted much influence on Indian science and technology. In the agricultural field the pressure of external forces was more visible and effective. Hence, this article tends to answer the following points: (1) What was the state of agricultural technology in India when the British took over? (2) Did the agricultural implements suit Indian conditions and needs? (3) What was the British response to Indian agricultural technology? (4) What did the British provide for its improvement? and (5) What was the response of Indian husbandman to Western techniques and technologies?

India has been known as an agricultural country, Indian people 'as a race of farmers', and Indian life as 'essentially a life of country'[1]. Agriculture in India had developed in remote antiquity, and down to the eighteenth century India ranked among a few developed countries of the globe. During the eighteenth and nineteenth centuries agriculture was really a vital industry of the people and with it were most closely linked all other local industries. It was on its development that the hope of raising the status of the people depended. Compared with it other industries took 'a lower room'[2]. Indian husbandman in the eighteenth century had a rich stock of agricultural techniques and implements. He used to employ a variety of instruments for husbandry purposes, some of which were introduced in England later.

Ploughs

Plough, the main instrument of cultivation, has been used in India since antiquity. Its structure and composition have changed according to needs and knowledge. When the British first established their rule over India in the 1760s, Indian husbandman was already in possession of different types of ploughs serving him on different soils and for different purposes (Figs. 1 and 2). The plough in Bengal was drawn by a single yoke of oxen guided by the ploughman. Two or three yokes of oxen, assigned to each plough, relieved each other until the work was completed.[3] In Gujarat it was a light and neat instrument. It had no cotter but had a sheathing of iron (Fig. 1). The furrows of the husbandman were straight lines of sufficient depth to produce abundant crops. The form of the plough in Malabar was nearly the same, but it was still lighter and more rudely constructed.[4]

Though the various ploughs used in different parts of India differed from each other in weight and effectiveness, the general pattern was the same for all. The part that penetrated the soil was a wedge-shaped stock of hardwood.[5] They served husbandman where the soil was light, unobstructed by stones and softened with water. All Indian ploughs were, however, not light. They had different patterns, intermediate in weight and effectiveness.[6] A heavier iron-shod plough was occasionally employed on ground that was rather stiff, or which had perhaps become weedy or less fruitful, and therefore, required somewhat deeper ploughing.[7] While in the alluvium of northern India and Bengal, a light plough with an iron soil-inverting mouldboard was useful, in Deccan the heavy implement to which four or six pairs of oxen were yoked was used to break the black soil into huge clods and it penetrated usually to 10 or 12 inches.[8]

Drill plough

The Indian husbandman has long been in possession of one of the most elegant and useful inventions in agriculture, *i.e.* the drill plough[9] (Fig. 3). The drill of Gujarat had three teeth about eighteen inches long, and ten inches as under. Through the upper end of each tooth, near the back was inserted a hollow bamboo of an inch in diameter, and about three feet in length. These three bamboos were set upright, and their upper ends were brought nearly together in the form of a triangle, and inserted through the bottom of a wooden cup. This apparatus was supported and made steady by cords, by way of shrouds which led to different parts of the plough.[10] In *southern parts* the *native drill* consisted of twelve bamboo teeth (Fig. 4). The sowing of grain was performed by a woman walking alongwith.

Two other ploughs exclusive of the common plough and the drill plough were also employed. One of these had a horizontal part and immediately followed the drill plough at work. It was set into earth about the depth of seven or eight inches and passed under three drills at once. It operated by agitating the earth so as to make the sides of the drills fall in, and cover the side grain, which it performed very effectively and left little trace of a drill. The other plough alluded to was used after the corn grows about eight or ten inches high. It cut up the weeds between three drills at once, and earthed up the roots of the corn at the same time.[11] This 'Weeding-plough' bore some resemblance to the English 'horse-hoe'. But the more common implement was the ordinary hoe, which resembled the English one shape, though its handle being short, the hoers in using it must take a sitting posture.

Harrows

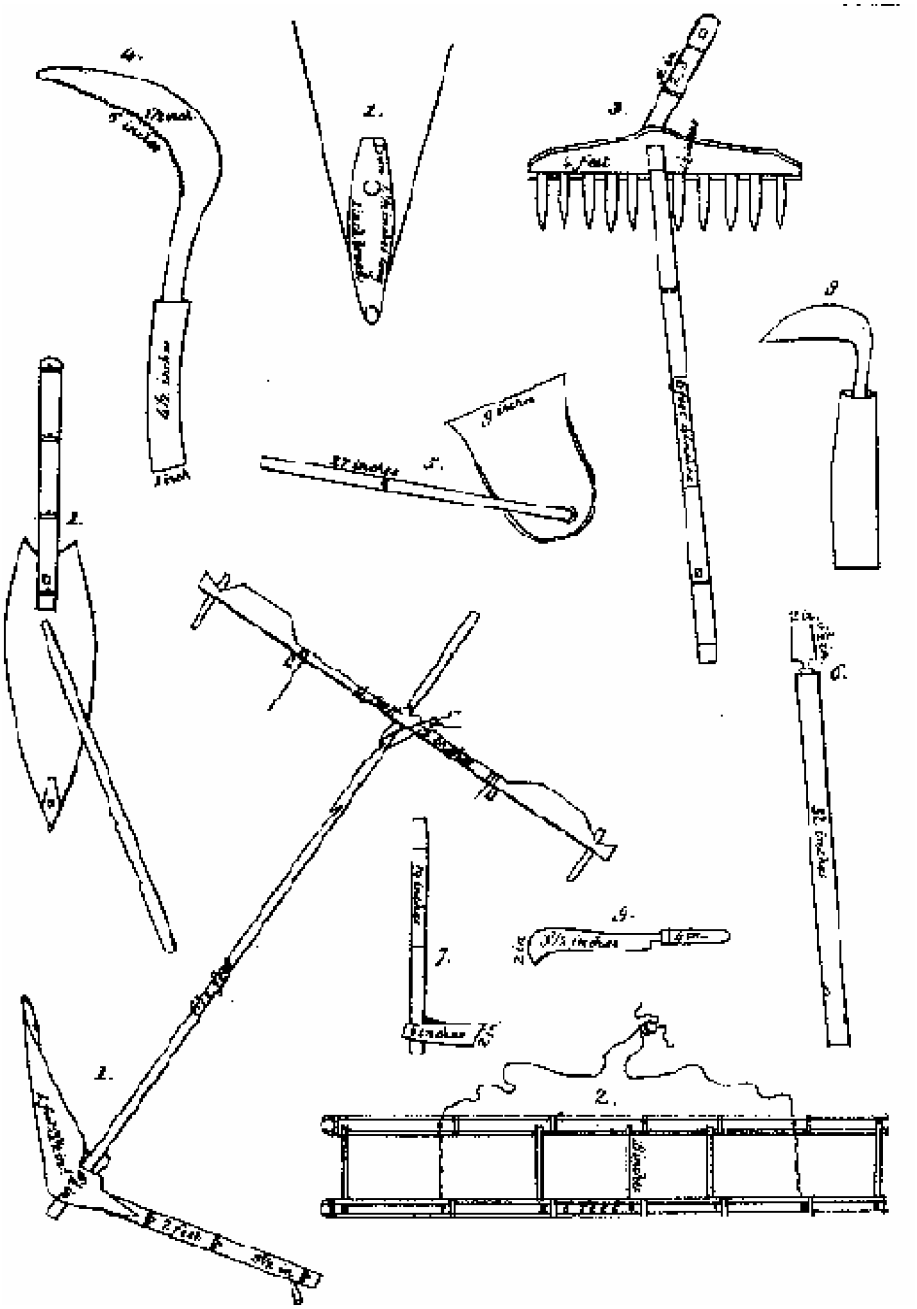
Besides the various types of ploughs, the Indian agriculture also benefited by the use of harrow. It consisted of a brand pierced with rough pegs, or more frequently of the bough of a tree on which one or two children seated themselves to give it the necessary pressure.[12] In the eastern parts of the country many farmers had the *bida* or rake drawn by oxen. It was usually provided with iron teeth, or at least the teeth were alternately of wood and iron [Figs. 1(3) and 5].[13] This implement was, however, not used in all soils. By the beginning of the nineteenth century a three or four cultured seed-drill had come in use for the purpose of harrowing with the seed bowl and seed tubes removed.[14]

Levellers and clod crushers

Usually two types of levellers were used by the Indian peasant to pulverize or to smooth the tenacious textured surface and also to conserve the moisture. One of these was the *moyi*, an implement made of two pieces of bamboo about six feet in length and joined together by some crow-bars like a ladder. When in operation, the ladder to which a pair of oxen were yoked, was drawn transversely across the field, while the driver stood upon it to give it weight [Fig. 1(2)].[15] The other, a still cruder contrivance was merely a thick narrow plank. It was in use both in Northern and Southern India. Dr. Francis Buchanan called it "the most awkward machine that I have ever beheld."[16]

Other implements

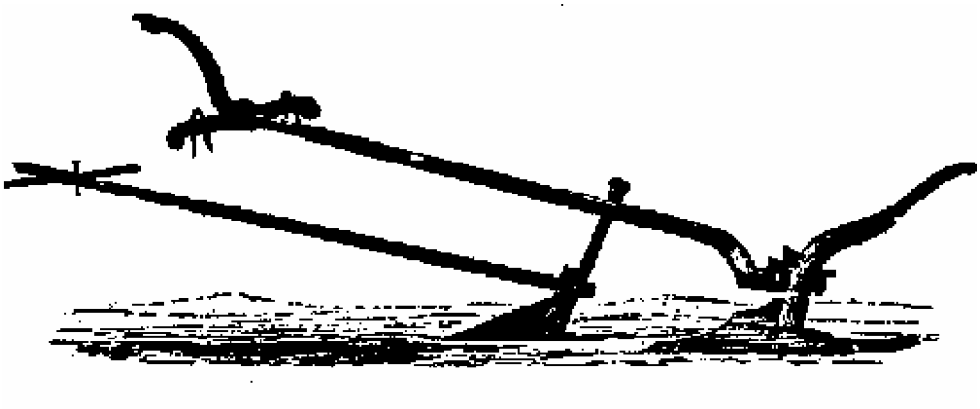
The Indian cultivator used to clear his fields both by hoeing and hand-weeding. In eastern parts of the country the implement to clear the fields was made of iron and was known as *pason* [Fig. 1(5)].[17] Mallets were used for breaking clods, with the usual assortment of hoes, harrows and rakes.[18] In Madras, heavy soils were dug with a crowbar called *khank* [Fig. 1(6)]. When the soil cracked in the hot season, the crowbar was inserted adroitly into the cracks and huge clods were levered out. In Bombay and Central India, the *vaddors* (professional diggers) used a strong blade of steel, 15 to 18 inches long, and about 3 inches wide at the point. The blade was fitted like a hoe to a powerful hardwood handle, 3 feet long. This implement was used with great effect on black soil when it cracked.[19]



1. Plough, 2. *Moyi*, 3. *Nangol* or *Bidle*, 4. Reaping hook, 5. Hoe, 6. *Khonk*, 7. Halchel, 8. Spud, 9. Bill

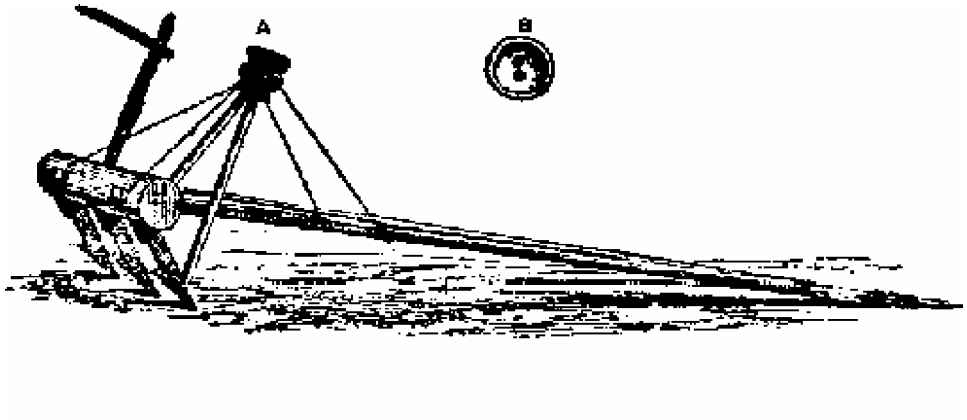
(From R M Martin, The History of Eastern India, London, 1833-38, Vol. II)

Figure 1. Implements of agriculture (eastern India).



(H. Beveridge, A Comprehensive History of India, London, 1872, Vol. II)

Figure 2. Ploughs – from native models in East India House.



(H. Beveridge, A Comprehensive History of India, London, 1872, Vol. II)

Figure 3. Drill of Baroach – from native model in East India House: (A) Cup drill, having two bamboos inserted in it; (B) Interior cup, showing holes where bamboos are inserted.

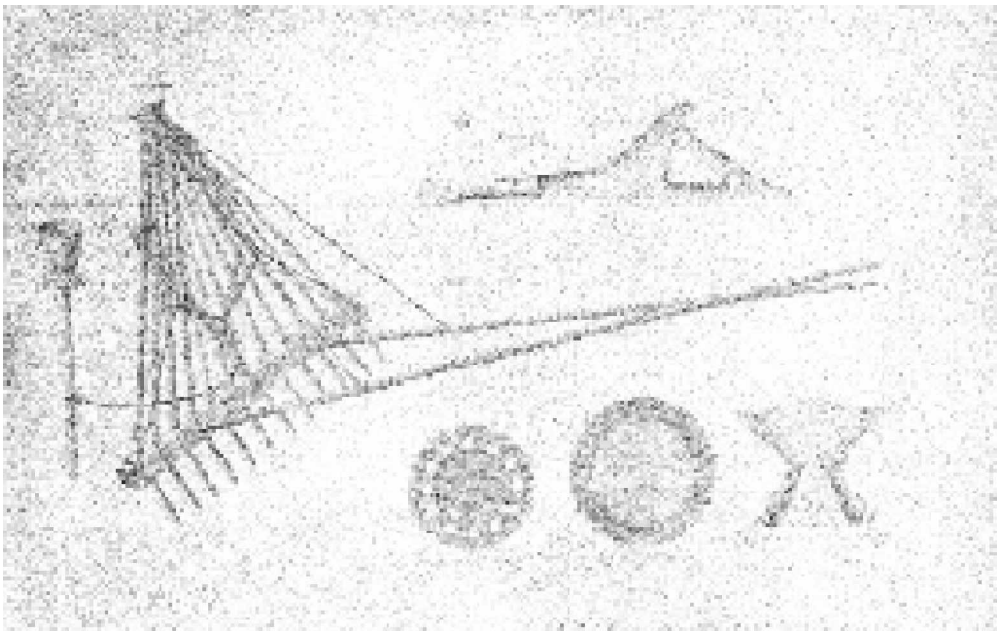


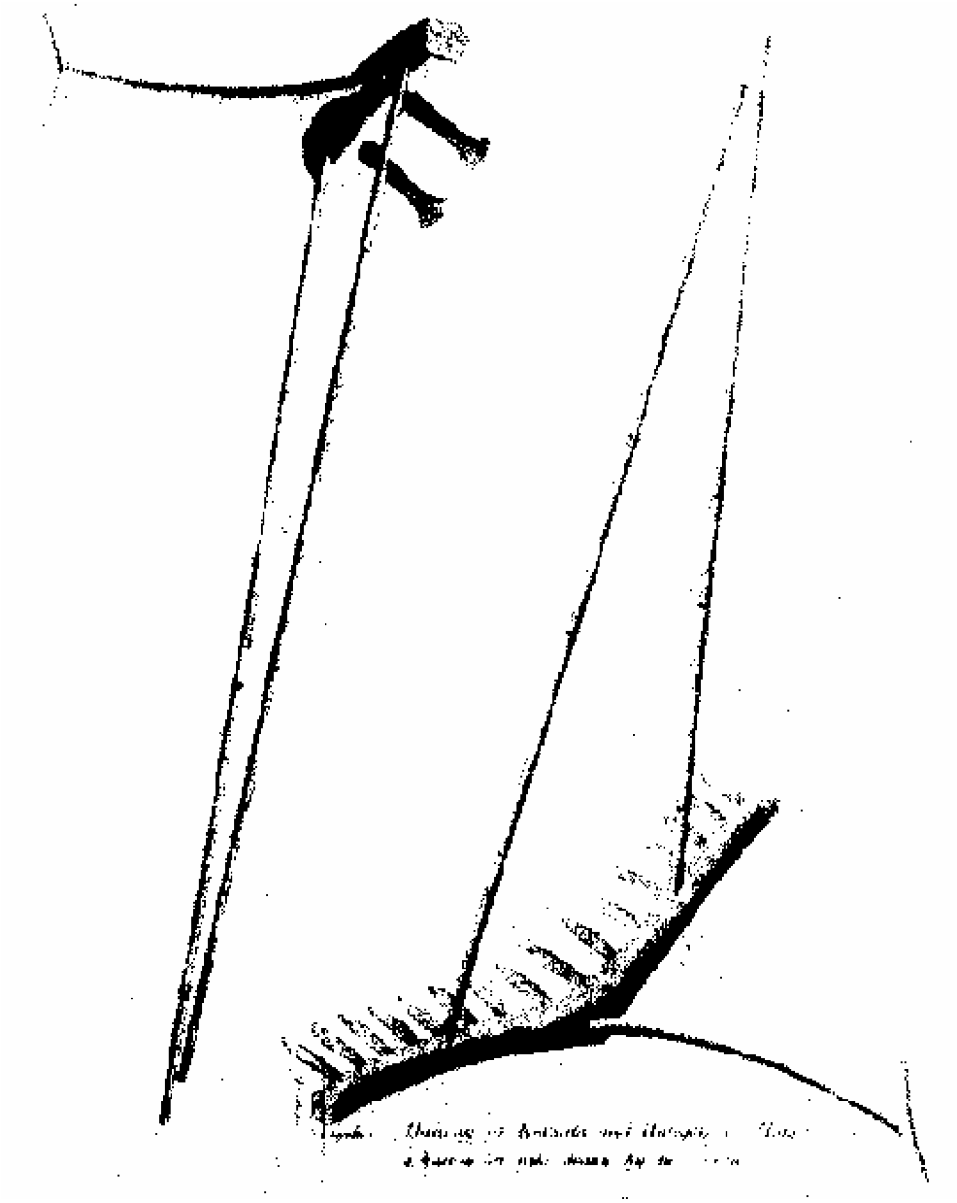
Figure 4. Native drill of southern parts.

The tool which was known in Europe as a spade or shovel was called in northern India *kodali,* and in the south *niamuti* [Figs. 1(7) and 7]. It consisted of an iron blade of varying width fitted to a wooden handle with which it made an acute angle. It was worked by the arms with the blade pointing towards the workman. It penetrated about 4 inches, and brought up the soil in large blocks which were left to weather down.[20] Voelcker was specially struck with the effectiveness of a small hand-pick in common use for digging holes to put seedlings into.[21] The original pick was made from the forked branch of a hard-wood tree, and picks of this character were extensively used in forest tracts. The indigenous iron pick was very much of the same shape while its size depended on the use it was put to. A small pick was used for lifting potatoes, turmeric, onions and crops of that class.[22]

Sickles used for reaping grain crops or for grass-cutting were generally of two types; the *harqsuya,* which had no teeth, and was the larger of the two (Figs. 7 and 8), and the *kachiya,* which had teeth and was small in size [Figs. 1(4) and 8]. In some parts the farmers used a large sickle called *jhapau* to cut grass.[23]

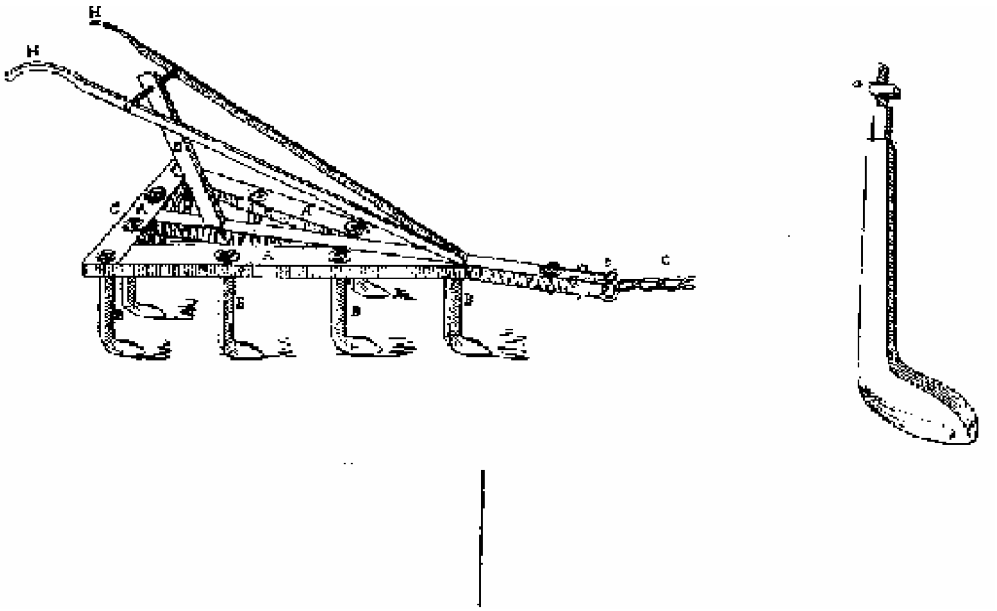
Sieves of bamboo or grass, and riddles of various patterns were used on threshing floor to handle the threshed chaff and grain, and to separate grain from chaff when the wind was not strong enough for winnowing in the usual way.[24] The winnowing scoop or *sup* was used in every part of India. The corn trodden out under feet of the bullocks mixed with the broken chaff *(bhusa)* was poured from a height when the wind was strong enough to carry away chaff and light grains. The good grain was further cleaned of earth particles and other impurities by means of the *sup.*[25]

Grain was ground into flour in the quantity required for daily use by means of the pestle and mortar.[26]



(From Francis Buchanan, A Journey from Madras Through the Countries of Mysore, Canara and Malabar, London, 1807, Vol. I)

Figure 5. A hoe and harrow drawn by two oxen.

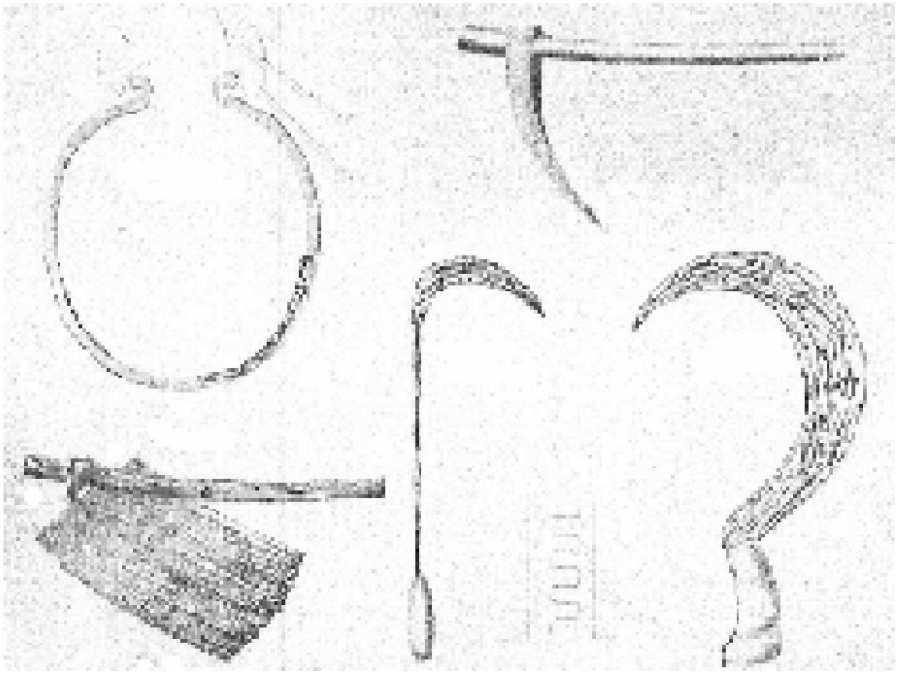


A side view of the instrument. Length from e to e 3 feet 6 inches.
A.A. The wooden frame into which the teeth are fixed.
B.B. Nine iron teeth.
C. The chain by which the instrument is dragged.
D. Support for the handles.
H.H. The handles.

One of the iron teech: Length 10 inches.
a. The nut and screw by which the tooth is fastened to the frame.
b.b. The edge of the tooth, tipped with steel.

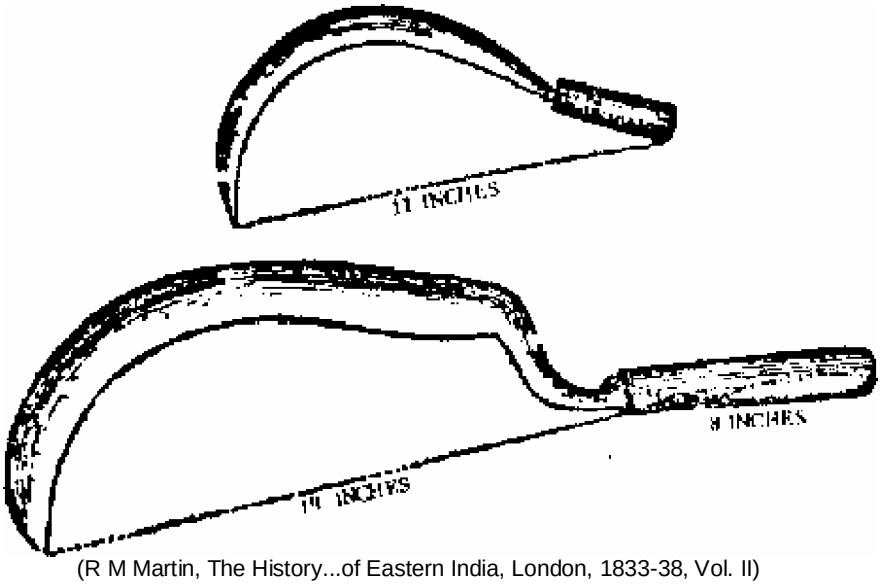
(R M Martin, The History...of Eastern India, London, 1833-38, Vol. II)

Figure 6. American cultivator.



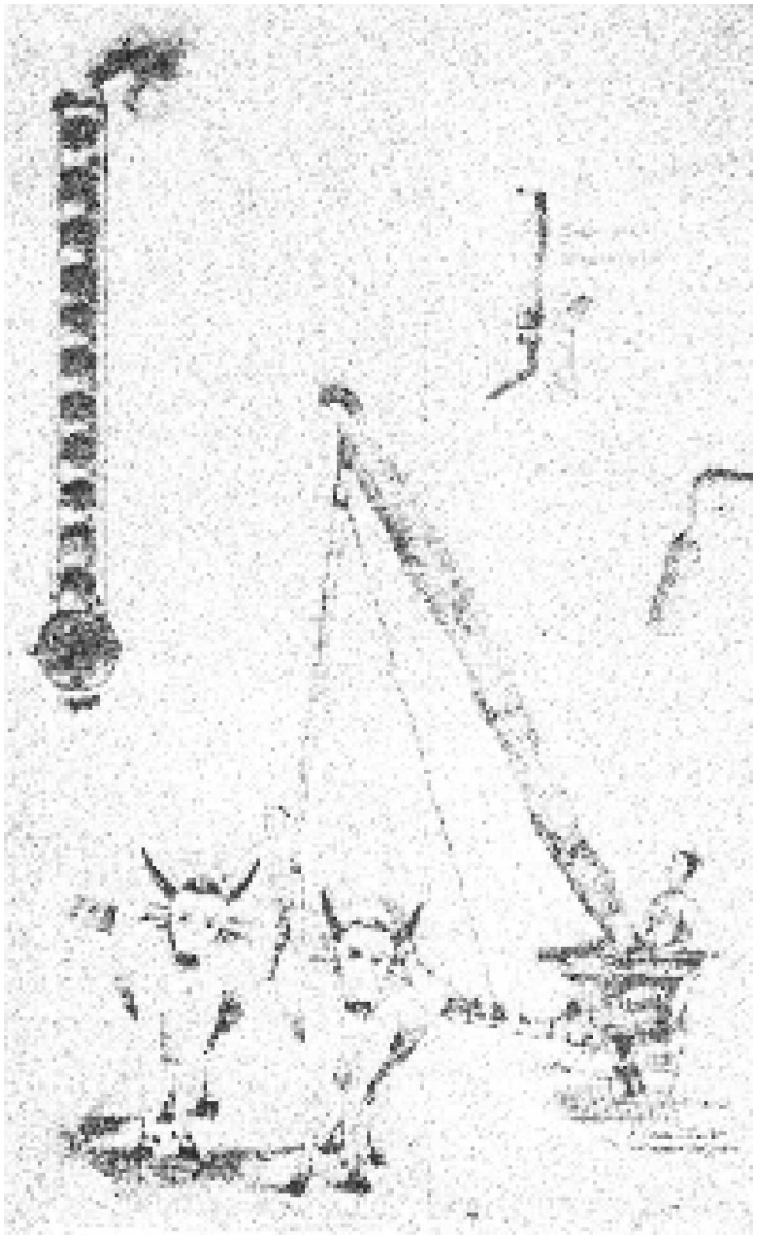
(From Francis Buchanan, A Journey from Madras Through the Countries of Mysore, Canara and Malabar, London, 1807, Vol. I)

Figure 7. Spade or *kodali*.



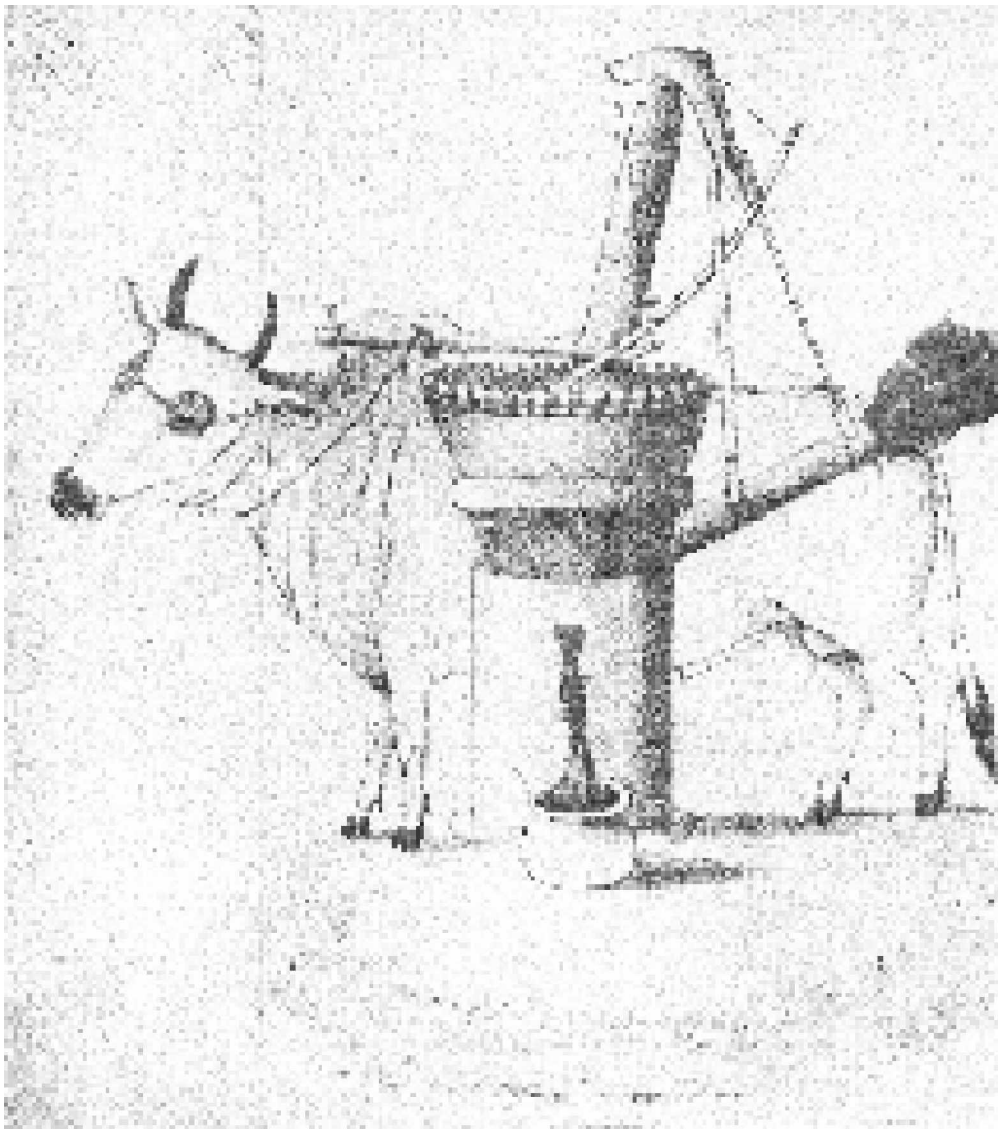
(R M Martin, The History...of Eastern India, London, 1833-38, Vol. II)

Figure 8. Sickles.



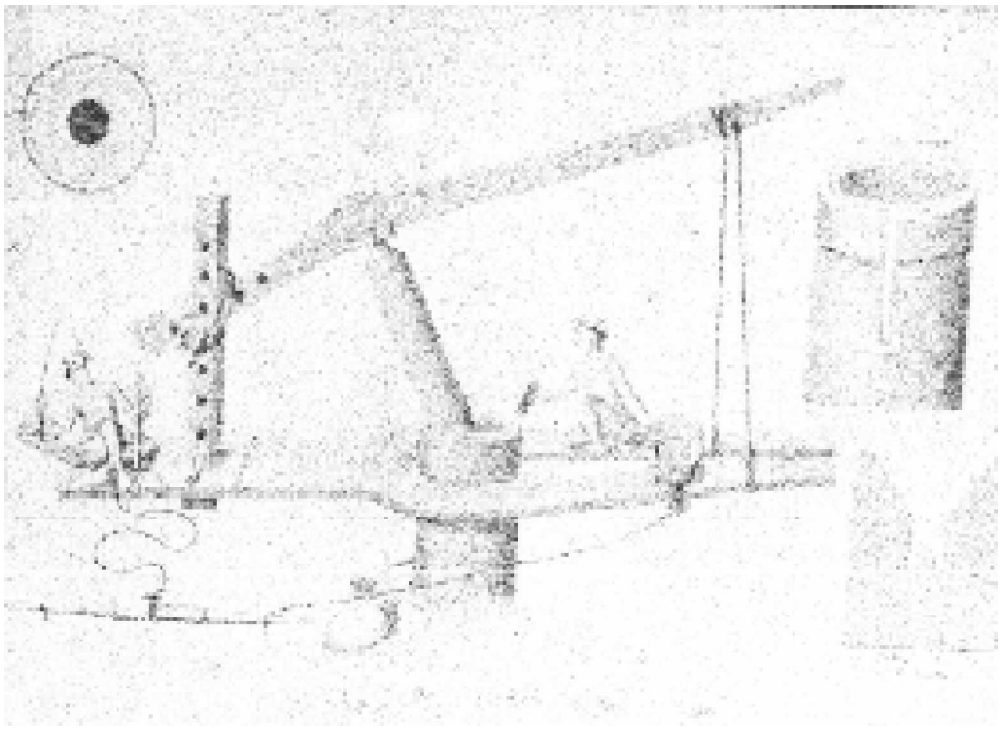
(R M Martin, The History...of Eastern India, London, 1833-38, Vol. II)

Figure 9. Mortar-and-pestle sugar mill of eastern and northern India.



(R M Martin, The History...of Eastern India, London, 1833-38, Vol. II)

Figure 10. Mortar-and-pestle sugar mill of Bengal and Bihar.



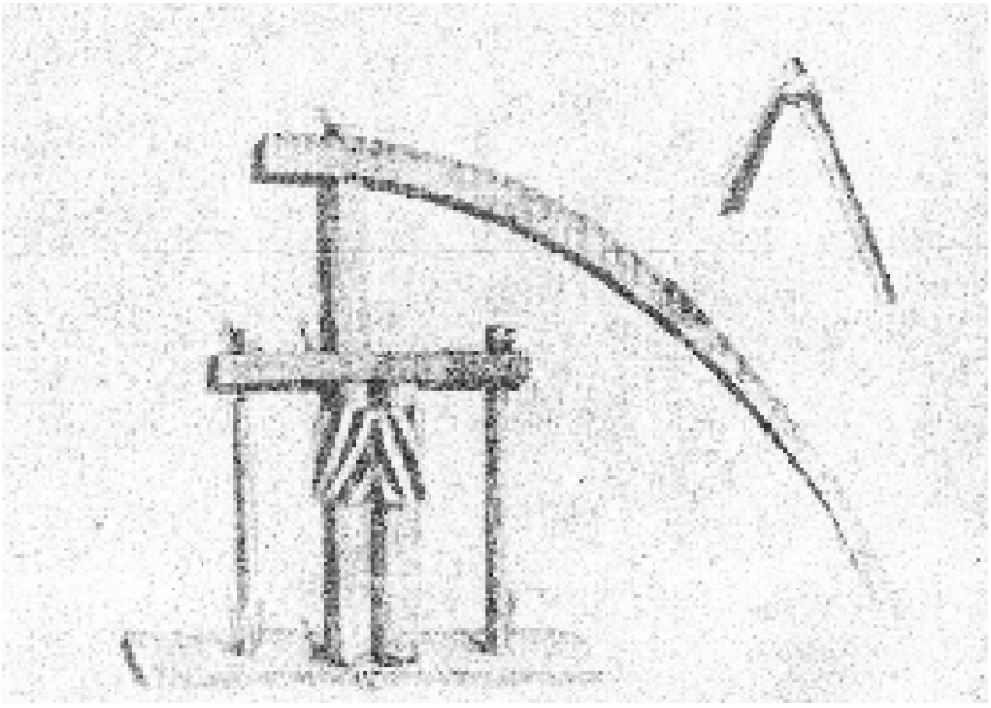
(From Francis Buchanan, A Journey from Madras Through the Countries of Mysore, Canara and Malabar, London, 1807, Vol. I)

Figure 11. Mortar-and-pestle sugar mill of South India.

Sugar manufacturing implements

The growing of sugarcane and the manufacture of sugar were practised in India since ancient time.[27] Sugar was manufactured on a large scale in Bengal and Bihar. Its quantity was not only enough for local consumption but also permitted export to Europe, Africa, America and some Asian countries.[28] Two types of technology are involved in its manufacture; the crushing of cane and the crystallization of the juice. Until the beginning of the nineteenth century, two methods of crushing sugarcane were generally reported. Firstly, there was the mortar-and-pestle mill similar to the oil-press (Figs. 9, 10 and 11). The mortar was good when made of stone, but in most areas this was found to be very expensive and hollowed wood was used instead. This mill was used throughout the Gangetic plains except in part of deltaic Bengal. It was also reported from Orissa, parts of Central India[29] up to Khandesh and in Rajasthan.[30] This method was, however, ill-suited to milling cane, as the cane had to be sliced first into short pieces and then dropped into mortar.[31] The second device, the wooden-roller-mill, involved the motion in opposite direction of two vertically mounted wooden rollers, one of which was rotated by oxen driven around it (Fig. 12). The main roller moved the other through ridges on its upper part fitting into grooves of the other. The canes were crushed by being thrust between the rollers.[32] This mill was employed in the southern zone extending from Gujarat and Maharashtra to coastal Andhra and Chhatisgarh.[33] In Punjab, geared wooden horizontal rollers were observed by Alexander Burnes (1830–33).[34]

An important development since the fourteenth century when the gearing-wheel was introduced in India by the invaders from Central Asia,[35] was the extensive use of wooden-roller-mills which in some parts of the country succeeded in replacing the customary mortar-and-pestle mills.[36] They dominated the scene until the last quarter of the nineteenth century when the iron-roller-mills were manufactured in India by Messers Mylne Thompson of Bihia (Fig. 13). By the end of the nineteenth century thousands of roller-mills were being made annually by Indian artisans.[37]



(From Francis Buchanan, A Journey from Madras Through the Countries of Mysore, Canara and Malabar, London, 1807, Vol. I)

Figure 12. Sugar mill (roller) of Chica Ballapura in South India.

Though the wooden-roller-mills were hard to work with and did the pressing ineffectively (the canes having to be passed through the rollers several times three or four, and sometimes as many as eight), yet they were preferred by the Indian peasants on various grounds. They could be made locally and the canes had not to be chopped up or cut into short pieces, as in the case with the *kolhu* and iron mills. Moreover, a wooden-roller-mill for crushing sugarcane could easily be maintained by an Indian *raiyat.* The whole expense of the sugar mill in the 1830s was about 31 rupees, and the machinery required to be renewed once in five years.[38]

Cleanliness, speedy transference to evaporating pans, rapid boiling, extent of surface exposed, removal of iron crystallisable matters, proper desiccation, and final careful storage are considerations which favorably influence the sugar production and show an important aspect of indigenous skills employed therein. The cane juice when squeezed out was evaporated and crystallized. The process and instruments employed for making either the cake called *jaggery* or 'sugar in its natural state', were more traditional than ingenious[39]. The pans for the evaporation of juice were made of earthen vessels. They were narrow and deep letting the impurities to find their way into the juice. A major development of the period was the steady use of broad shallow pan that gave much less opportunity for secondary fermentations setting in. In Palamau (Bihar) the shallow pan was in use by the second half of the nineteenth century, but not in Coharadaja and Dacca where earthen pans were employed. In Gujarat the use of the shallow pan was universal but it was not known in Bassein, where deep narrow pans were in use.[40]

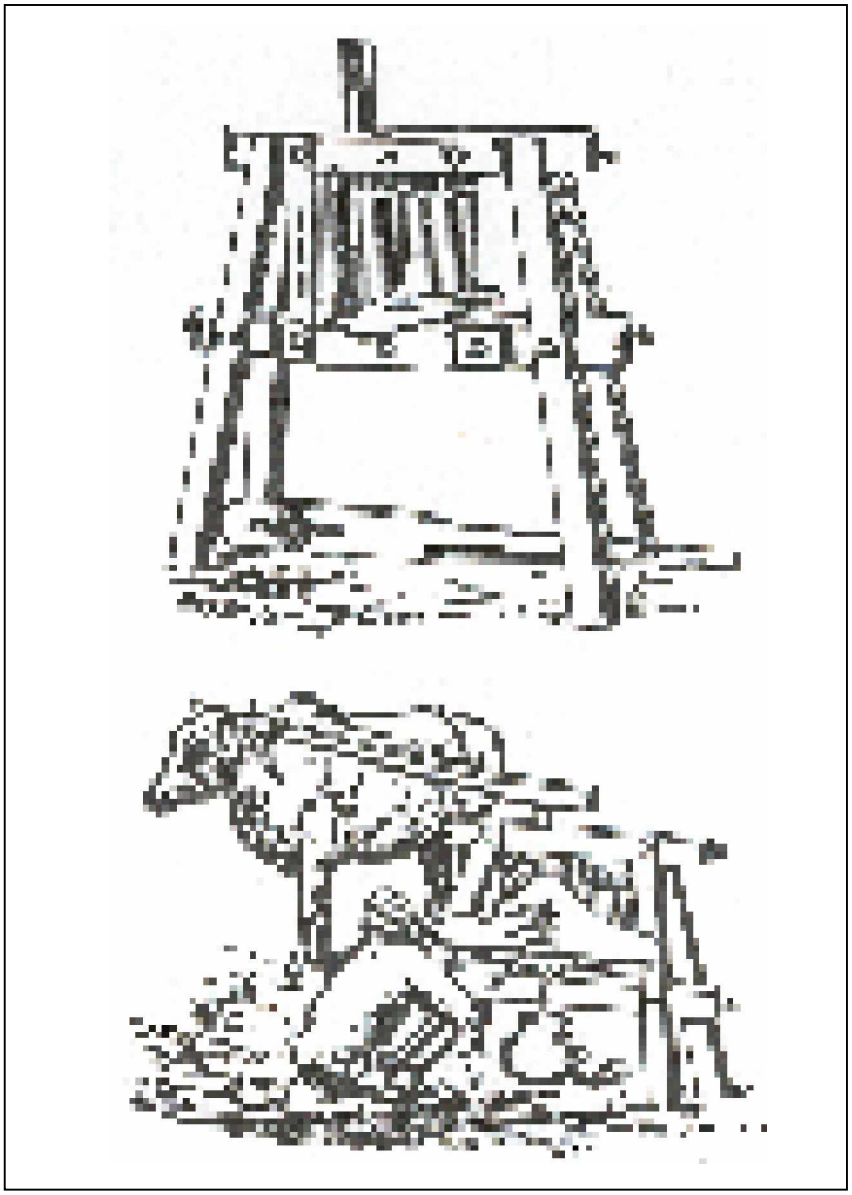


Figure 13. The Beheea sugar mill.
[The Beheea sugar mill introduced into Bihar in 1873. Initially it had two rollers (as on top). In 1880, a three-roller-mill was introduced (as below)].

The Indian cultivators thus relied more on the customary and traditional technology employed in crushing sugarcane and crystallizing the cane juice. The rollers were made either of stone or wood. Iron was still out of the reach of common peasant, a 'major obstacle, in fact, for the further progress of the industry'. Its lack of use was largely due to its high cost.[41] Whereas the crushing of sugarcane was primitive and defective in the sense that the stone rollers could not squeeze out the juice completely, the Indian method of preparing sugar too did not develop further. The diffusion of new technologies from the west was not marked until 1870. The only change of the period was that the mortar-and-pestle mills were replaced by roller-mills in some parts of India.

From the above description we find that the implements employed by Indian agriculturist at the establishment of the British rule in India were traditional, handed down from generation to generation. The eighteenth century did not produce a break in the agricultural technology of India. On the other hand, this period (1757–1857) in European history was a period of remarkable developments, a period

of new inventions and innovations in technology. It also witnessed active co-ordination between professional scientists and skilled technicians. In the field of agricultural technology also some new implements were introduced.[42] Having established their hegemony over the coastal tracts of India in the 1750s and down to the great uprising of 1857, the East India Company exhibited its interest in the development of Indian agriculture on account of improved techniques and technologies. They had mixed reactions about Indian agricultural implements due to their construction, consumption, ability and effectiveness.

The Indian wooden plough was one of those agricultural implements, which the British considered 'imperfect in the extreme'.[43] The plough had neither coulter nor mould-board, nor had it the share of sufficient depth, either to penetrate the soil above 3 inches deep, or to turn over any part of it.[44] The handle too was so badly constructed as to give the ploughman scarcely any power of directing it. Several ploughs in succession deepened the furrows, or rather scratched the surface. Indian ploughs were thus considered no ploughs at all but mere 'grubbers, which stir up the soil without inverting it.'[45]

The Company therefore tried to introduce and popularise the improved ploughs among the Indian cultivators.[46] Experimental Farms were established at some places where the new instruments and latest techniques were tried.[47] By the end of the nineteenth century almost every Government Experimental Farm had its 'pet plough'; the *Kaisar*, the *Duplex* and the *Watts* plough at Kanpur, the *Saidapet* and the *Massy* ploughs at Madras, the *Stormont* plough at Khandesh and the *Seebpore* plough in Calcutta. The heavy *Hindustan* (Aveoys) plough was used by the Indigo planters in Bihar. Likewise the American cultivator (Fig. 6) was pressed into service in the cotton growing districts of western India.[48]

The response of Indian cultivator to these instruments was, however, not encouraging. He found many difficulties with the improved iron plough supplied to him by the British. The Salsette husbandman objected that the plough was too heavy and that the labourer and his oxen were needlessly fatigued.[49] The Royal Commission on Agriculture in India also referred to this fact in its report of 1928 and noted that the reluctance of the cultivator to adopt improved implements was due for more to his preference for implements he can carry to and from his fields than to any serious deficiency in draught power.[50] Furthermore, the bullocks which the Indian cultivator yoked to plough his fields were not strong enough to work with heavy plough suggested by the British.[51]

The "cost of iron plough also militated against its adoption."[52] The improved plough's cost was beyond the reach of a poor Indian *raiyat* who used to produce more to subsist his needs than to any profit motive. The village carpenter used to make a plough of *babul* wood for the cultivator who "bought an iron share in the *bazar* for 4 annas".[53] The first cost of an Indian plough would be, thus, but a few shillings whereas the improved plough was an expensive machine.[54]

Furthermore, the proprietor of an iron plough had to own a small foundry to execute the repairs there.[55] But in the case of his native plough the *raiyat* got the services of the village carpenter easily and for cheap costs. There was, thus, "no chance for the replacement of the native wooden plough by the iron plough until the difficulties as to initial cost and repair can be met."[56]

The main objection expressed by the British technicians to the Indian wooden-plough was that its wooden-share did not invert the soil and went deep only to three or four inches. They cited the reploughing and cross-ploughing by the Indian plough as clues to its inability to go deep enough and to invert the soil once for all. The Indian cultivator was, however, well aware of the nature of his soil which at the surface, well-heated by exposure to the sun, was that which yielded the best return.[57] He had known from experience that in a climate where the productive powers were great, it was only necessary to put the seed a slight way into the ground. If it was buried deeper, it would rot and decay before it could germinate, or it would remain dormant in the earth.[58]

Other agricultural implements were also denounced for being simple, clumsy and rude,[59] as "they are all manufactured, changed and repaired in the village without any assistance from skilled mechanics.[60] This, however, does not make the tools less useful. Simplicity cannot be surely counted a fault. In

some of the British districts the plough was by far too complicated a machine.[61] The Indian plough had still many qualities which rendered it peculiarly suited to the genius of the Indian cultivator.[62]

Agriculture implements employed by an Indian cultivator during this period, on the whole, were well suited to local conditions. They were within the capacity of the draught oxen, comparatively inexpensive, light and portable, easily made and what is perhaps of even greater importance, could be readily obtained.[63] One difficulty with the British observers was that they began the crusade without studying the Indian conditions.[64] Their knowledge about agricultural implements was best suited only to British conditions. Any attempt to test the merits of Indian agriculture merely by comparing it with British agriculture was misleading. The judgement of the eye decides more than one can imagine. The village taste set the standard of quality. The existing agricultural practice of India was based on the accumulated experience of years. There was no school like that of experience.[65] Indian husbandman was well aware of the nature of his soils and conditions of the uncertain weather. He could study the effects and appearance of his implements, which were in fact essential to his credit as good farmer.[66]

However, the preference of Indian cultivator to his traditional implements does not mean in any case that Indian agriculture technology had left no scope for further improvement. Implements are always worthy of improvement in whatever developed state they may be. The essential factor is necessity. The implements used by Indian cultivator were suitable and in a developed state, but only to the conditions under which and for the needs for which they were employed. If the British implements were not appreciated and welcomed with craze by Indian cultivator in the beginning, it was because they had been introduced before changing the existing conditions.[67] The new devices were not rejected on account of their 'external' label. Besides, Indian husbandman was not absolutely destitute of enterprise and opposed to all improvements.[68] Since the last quarter of the eighteenth century and down to the replacement of Company rule by that of the Crown in 1858 the Indian husbandman adopted many things from Europe and he was continually adding when it suited his taste and convenience.[69] The most remarkable aspects of improvement were the steady use of iron in place of wood in agricultural implements, the use of iron-share in the native plough and the replacement of mortar-and-pestle mill for crushing sugarcane by wooden or stone roller-mills, *etc.* The extensive use of water-power is yet another feature of technological innovation of the period.[70]

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   Sir Henry M. Elliot (1844) also speaks of the use of drill plough in sowing. See his *Memoris of the History, Folklore, etc. of the North Western Province of India,* (ed.) J. Beams, London, 1869, Vol. II, pp. 341–342; George A. Grierson, *Bihar Peasant Life,* Calcutta, 1885 (reprint Delhi, 1975), pp. 4–5. For its use in South India, London, 1810–17, Vol. I, p. 209. In Eastern India the machine was known as *Chongga.* Martin, R.M., *History, Antiquities, etc. of Eastern India,* London, 1838, Vol. III, p. 266. For the use of drill-plough in Western India, A. Mackey, *op. cit.,* p. 44.

10. Holcott, Captain Thos, *op. cit.*
11. Beveridge, H., *A Comprehensive History of India: Civil, Military and Social,* London, 1862, Vol. II, p. 155.
12. Capper, John, *op. cit.,* p. 317.
13. Martin, R.M., *op cit.,* Vol. II, p. 214.
14. *Imperial Gazetteer of India,* pp. 15–16.
15. Beveridge, H., *op. cit.,* p. 153.
16. Speaking of it in his report on the district of Purnea, he says, "There is no handle to it, as there is to the planks used for a similar purpose in the South of India; nor have the natives had the ingenuity to fasten a beam to it, by which it might be drawn." Martin, R.M., *op. cit.,* Vol. III, p. 266.
17. *Ibid.,* p. 267.
18. Walker, Sir Alexander, *op. cit.,* p. 185.
19. *Imperial Gazetteer of India, op. cit.*
20. Voelckar, J.A., *Report on the Improvement of Indian Agriculture,* London, 1893, p. 223.
21. *Ibid.*
22. *Imperial Gazetteer of India, op. cit.*
23. Martin, R.M., *op. cit.,* Vol. II, p. 214.
24. *Imperial Gazetteer of India, op. cit.*
25. *Ibid.;* Beveridge, H., *op. cit.,* pp. 154–155.
26. *Ibid.*
27. Every mention of it from the various passages in *Scriptures* down to the beginning of the Christian era is simply that of a "sweet cane" or a "fine kind of honey found in an Indian reed". Herodotus alludes to "honey made by the hands of men, but gives no details. Lucan speaks of the sweet juice expressed from reeds, which the people of India were fond of drinking. Still much later Arrian described honey from reeds called *sacchar*, as an article of trade between the Indian ports and the countries of the Red Sea". John Capper, *op. cit.*. pp. 325–326.
28. Splinter, Stavorinus John, *Voyages to the East Indies, 1768–71,* London, 1798, Vol. I, p. 140; Ward, W., *A View, etc.,* London, 1817–20, Vol. I, pp. 83–85.
29. Sleeman reported in 1835–36 that in Central Province near Jhansi mortar-and-pestle sugar mills were employed. Sleeman, W.H., *Rambles and Recollections, etc.* Westminster, 1893, p. 207.
30. For the use of mortar-and-pestle in Bihar see G. Grierson, *op. cit.,* pp. 50–55; for N.W. Provinces, Further, A., *Monumental Antiquities & Inscription in the N.W. Provinces,* Allahabad, 1896, pp. 87–319; for U.P., Heber, R., *Narrative of a Journey Through the Upper Provinces of India 1824–1825,* London, 1828, Vol. I, pp. 523–524.
31. Martin, R.M., *op. cit.,* Vol. II, pp. 878–879.
32. Voelckar, J.A. *op. cit.,* p. 224.
33. As early as 1695 Careri observed at Basseni near Bombay "sugarcane pressed between two great wooden rollers turned about by oxen, whence the cane came out thoroughly squeezed." *The Indian Travels of Thevenot and Careri,* (ed.) S.N. Sen, Delhi, 1949, p. 169.
34. Burnes, Alexander, *Travels in Bokhara,* London, 1834, Vol. I, p. 44. For the use of wooden or stone roller mills in Bengal see F. Buchanan (1808) in R.M. Martin, *op. cit.,* Vol. II, pp. 878–879. For Uttar Pradesh, Heber, R., *op. cit.*. Vol. I, p. 416; Vol. II, p. 252; Elliot, H.M., *op, cit.,* Vol. II, pp. 375–376; Atkinson, *Gazetteer of North Western Provinces,* pp. 411–412.
35. Prof. Irfan Habib has discussed in details the major technological changes that took place in India during the 13th and 14th centuries through the Ghorian invaders. Habib, Irfan, 'Changes in Technology in Medieval India', *Studies in History,* Vol. II, no. 1, 1980, pp. 15–39.
36. Sleeman, W.H., *op. cit.,* p. 208.

37. Voelckar, J.A., *op. cit.*, p. 225; *The Imperial Gazetteer of lndia,* p. 41; *The Punjab Administration Report* of 1989 speaks of the Bihia sugar mill as being "the only implement successfully introduced into the Punjab in late years. In Rohtak it drove the old *Kolhu* out of use and in Kapurthala the substitution of it for wooden mills was actively encouraged."

38. Martin, R.M., *op. cit.,* Vol. I, p. 290. In the 1890s while the wooden mill cost Rs. 20/- to Rs. 30/- the two rollers iron mill cost from Rs. 80/- to Rs. 100/-. Voelcker, J.A., *op. cit.,* pp. 224–225.

39. Arrian, *Periplus of the Red Sea* quoted in John Capper, *op. cit.,* p. 325; Voelcker, J.A., *op. cit.,* p. 251.

40. *Ibid.,* p. 226.

41. Its price in about 1595 is estimated in terms of wheat to have been three times what it was in 1914. Moreland, W.H., *India at the Death of Akbar,* London, 1920, pp. 150–151. *Ain-i-Akbari* maintains it worth only double. Vol. I, p. 138.

42. Derry, T.K. and Williams, T.I., *A Short History of Technology from the Earliest to A.D. 1900,* Oxford, 1960, pp. 668–674.

43. Murray, Hugh, *Historical Accounts of the Discoveries and Travels in Asia from the Earliest Age to the Present Time,* Edinburgh, 1820, Vol. II, pp. 230–231.

44. *Ibid.;* Wallace, R.G., *Memories of India, etc.,* London, 1824, p. 94; Munro, Innes, *A Narrative of the Military Operations on the Coromandel Coast etc.,* London, 1789, p. 81; Buchanan, F., *Journey from Madras, etc.,* London, 1807, Vol. I, p. 126; Bevan, Major H., *Thirty Years in India,* London, 1839, Vol. II, p. 249.

45. Fuller, Sir B., *Studies in Indian Life and Sentiments,* London, 1910, p. 149.

46. At some places cultivators were supplied with improved implements, seed and cattle free of cost. "In Salsette some active and enterprising husbandmen who had but few prejudices, were procured, and a village was built for them. They were furnished with seed and cattle. Walker, Alexander, *op. cit.,* p. 183.

47. In Bengal there were the *Sibpur Govt. Farm, the Burdwan Raj Farm* and the *Dumraon Raj Farm;* in the N.W. Provinces and Oudh the *Cawnpore Experimental Farm;* in Madras the *Saidepet Govt. Farm;* in Bombay the *Govt. Farm at Nagpur.* Besides, there were some minor farms in Punjab, Assam and Burma. See Bose, P.N., *op. cit.*, pp. 208–209.

48. Voelckar, J.A., *op.cit.,* p. 216.

49. Walker, Alexander, *op. cit.,* p. 183. "The native plough, generally speaking, weighs about 25 lbs, some were even lighter. The *Konkan* plough for example, weighs only 20 lbs, while an improved plough will weigh from 30 lbs to 890 lbs." Voelckar, J.A., *op. cit.,* p. 217.

50. *Report of the Royal Commission on Agriculture in India,* 1928, p. 110.

51. Long, J., *Wanderings in India,* London, 1859, pp. 351–352.

52. *The Imperial Gazetteer of India,* p. 12.

53. Voelckar, J.A., *op. cit.,* p. 216.

54. Holcott, Captain Thos, *op. cit.,* p. 211. "In Eastern Bengal a wooden plough costs 8 annas only. But Rs. 2/- to 4/- may be considered the general range of prices throughout India, while the cheapest improved plough will cost Rs. 5/- to 6/-." By the end of the nineteenth century the rate of some improved ploughs were as follows: The *Duplex,* Rs. 5/-; The *Kaisar,* Rs. 6/-; the *Seebpore,* Rs. 6/-; the *Watts,* Rs. 7/-; the *Saidapet,* Rs. 8/-; The *Hindustan,* Rs. 12/-; Voelcker, J.A., *op. cit.,* pp. 216–217.

55. At Bellary one Mr. A. Subapathi Mudliar, who sold a number of Swedish ploughs, had to maintain a factory for repair. In another case Mr. Subanayagam Mudliar at Shiyali had his own repair workshop: Voelcker, J.A., *op. cit.,* p. 218.

56. *Ibid.,* p. 229.

57. Walker, Sir Alexander, *op. cit.,* p. 199.

58. *op. cit.,* p. 181. Later scientific observations have disapproved the idea of deep plough in India. Conserving moisture, exposition of weeds and slices to the sun, availability of limestone and *kankar* into the depth of the soil and the uncertainty of rainfall, all these factors affirmed the preference of Indian husbandman to his

wooden shared plough against deep ploughing. Voelckar, J.A., *op. cit.*, pp. 220–222; *The Royal Commission on Agriculture in India*, 1928, p. 110.

59. Orlich, Leopold Von, *Travels in India*, London, 1845, Vol. II, p. 76; Innes Munro, *op. cit*. Mulburn remarked in 1813 that agriculture was conducted in India with the most frugal simplicity. Milburn, W., *Oriental Commerce*, London, 1813, Vol. II, p. 270.
60. Bose, P.N., *op. cit*., Vol. II, p. 170.
61. Walker, Alexander, *op. cit.*, p. 185.
62. Long, J., *op. cit.*
63. The Royal Commission on Agriculture in India also submitted to these facets of Indian agricultural implements. *Report, etc., op. cit.*, p. 107.
64. "With the enthusiasm that developed among the British civil servants in India for the development of Indian agriculture, preference for all that is western; that any thing that is good must come from the west." Mackenna, James, *Agriculture in India*, Calcutta, 1915, p. 7.
65. *op. cit.*, pp. 28–29.
66. In 1846 Mr. S. Mansfield, one of the collectors of the Southern Maratha country was shared by the American planters in his view that "the Indian system of agriculture was not only well suited to the country, but that this system was better for India than the American plan." Walton, W., *A Short History of Cotton: its Culture, Trade and Manufacture in the Bombay Presidency*, Bombay, 1880, p. 97.
67. In 1928 the Royal Commission on Agriculture in India observed that "the conditions in which the original cultivator works suggest no improvement." *Report, etc., op. cit.*, p. 14.
68. Crooke, W., *op. cit*., p. 331.
69. Walker, Sir Alexander, *op. cit.*, p. 198.
70. In the 1820s the use of water-power was rare. One such water mill to grind rice was observed by Bishop Heber at Almorah. "Though exceedingly crude, it was of some sort as in other countries", and was even ranked as "the finest specimen" found in India. Heber, R., *op. cit.*, Vol. I, pp. 478–479. But then the reopening of the Delhi Canal in the 1820s rendered invaluable source of power for the flour-mills at Karnal and Delhi. See Baird Smith, 'Canals of Irrigation in the N.W. Provinces', *The Calcutta Review*, Vol. XII, no. xxiii, p. 95.