simulations with the same may take significant time, not allowing any lead time to release the forecast of flood inundation. Hence a data bank was initially prepared (which will be extended and updated in future with more scenarios) with 796 scenarios resulting from rainfall extremes corresponding to different return levels, the tide of different levels of severity, and past conditions of rainfall. As soon as the forecast is released, a search will take place in the look-up table developed based on the scenarios and flood inundation for the closest scenario will be provided as the initial forecast. The flood inundation will be forecasted for different quantiles of rainfall (Figure 3). If both 95th and 99th percentile inundation show severe flood, a real-time flood simulation will be started with real-time forecasted and monitored data to provide updates about the flood situation. The entire process is automated as an expert system to provide reliable inundation at real time. A typical visualization of such inundation is also presented in Figure 3 and more detailed visualization at ward level is being implemented by NCCR in the C-FLOWS interface.

The entire expert system has now been transferred to NCCR, Chennai for day-to-day operations. This is implemented in the C-FLOWS by NCCR. The developed system must be continually maintained by incorporating modifications to the model parameters to reflect changes in land use, storm-sewer network and other hydraulic interventions so that it is always up-to-date for use during floods, with a high reliability.

1. Sarkar, A., Paromita Chakraborty, John P. George and Rajagopal, E. N., Report, NMRF/TR/02/2016, 2016; https://www.ncmrwf.gov.in/Reports-eng/NMRF_TR2_2016.pdf
2. Shastri, H., Ghosh, S. and Karmakar, S., *J. Geophys. Res. Atmos.*, 2017, **122**(3), 1617–1634.
3. Thiruvengadam, P., Indu, J. and Ghosh, S., *Adv. Water Resour.*, 2019, **126**, 24–39.
4. Luettich Jr, R. A. and Westerink, J. J., *Int. J. Numer. Methods Fluids*, 1991, **12**(10), 911–928; https://doi.org/10.1002/fld.1650121002.
5. Mohanty, M. P., Sherly, M. A., Karmakar, S. and Ghosh, S., *Water Resour. Manage.*, 2018, **32**(14), 4725–4746.

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Development of eco- and textile industry-friendly, short-statured hirsute cotton variety, Indica

Cotton is one of the most important crops interlinked with culture, civilization and economy of mankind. It provides fibre, food-related products, including vegetable oil, protein and also cellulose for making plastics and explosives. Among the different species of cotton, *Gossypium arboreum*, *G. herbaceum*, *G. hirsutum* and *G. barbadense* are being cultivated in 122.35 lakh ha in different ecosystems like rainfed system with assured rainfall and irrigated situations, and also rice fallows in India. Annually 35.1 million bales of cotton is being produced in India, contributing to about 14% of industrial production and 4% of the gross domestic product[1]. The native species *G. arboretum* and *G. herbaceum*

were predominately cultivated in earlier times. Since their yield was poor, high-yielding cotton species of good quality *G. hirsutum* and *G. barbadense* were introduced in India from other ecological zones of the world, to meet the demands of the growing population. The exotic species of cotton have different morphological features and growth habits. They are able to grow in India with the use of synthetic fertilizers and other chemicals[2]. The cotton crop is known to utilize about 6% of total fertilizers and 45% of pesticides compared to other agricultural crops in India[3]. A study was conducted to develop a non-bushy, short-statured, hirsute cotton variety with open canopy that matures in a shorter period compared to some other popular varieties of cotton grown in India. This variety shows better penetrability of applied insecticides giving good yield of quality fibres having high degree of polymerization. The results are presented in this correspondence.

The variety Indica was developed by hybridizing two short-statured hirsute strains, viz. 70E and CAKD (Figure 1 *b*). The F1 seeds from a single boll were used for raising the progenies. Pedigree method was employed for further selection of progenies with high single plant yield of desired fibre quality. The materials were advanced in succeeding generations by selfing. On stabilization, they were tested for four years in the village farms on one acre plots following the recommended agronomy[4]. The hirsute varieties that were popularly grown in these villages, viz. MCU5, MCU5 VT and Surabhi were used for comparison. The seed cotton yield was recorded and quality of the fibres was assessed using HIV instrument. The degree of polymerization of cotton fibres of different varieties was assessed using the IS 244 method.

Indica has sparse, open-type canopy and grows to a height of 120–130 cm. It has short internodes and develops 16–18 boll-bearing sympodial branches, and matures in 130 days. The sympodial branches are capable of growing further in the event of shedding of buds, flowers and bolls due to insect bites and other biotic and abiotic changes and produce new reproductive parts to compensate for the losses, if any (Figure 1 *a*). This is a unique trait that does not exist in other popular varieties, including hybrids. Since the plants of Indica have open canopy and boll-bearing branches are well exposed, they only require 4–5 applications of pesticides, as the applied pesticides reach the desired sites and cause less pollution as a drift. The open-type canopy of Indica also enables easy harvest of seed cotton, both by manual and mechanical means.

The productivity of Indica was assessed in the farmers' fields having different soil types in some villages in TN along with the commonly grown popular varieties in the villages. The results show that Indica recorded a higher yield of 2246 kg/ha as against 1973, 2020 and 2100 kg/ha recorded by the other hirsute varieties, viz. Surabhi, MCU5 and MCU5 VT respectively (Table 1).

The quality attributes of the fibres of Indica such as ginning outturn, lint and seed index, including strength and micronaire were almost the same as those of other varieties. However, they differed in respect of length of fibres recording 34.27 mm, while other varieties had a fibre lengths ranging from 23.5 to 33.55 mm (Table 2 and Figure 1 *b*). The most important character of cotton fibres is the degree of polymerization (DP), as it is associated with higher yarn/fibre strength. During chemical processing like bleaching, the chemicals used reduce the DP and the fabric gets weakened. A

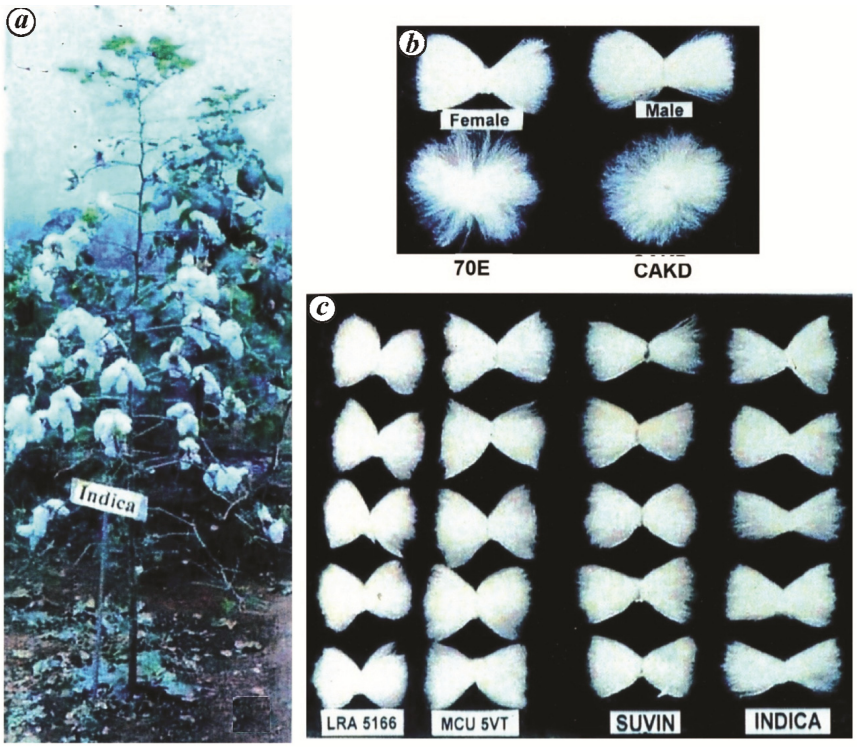

Figure 1. (***a***) Morphological features, (***b***) combed seed cotton of the parents of Indica and (***c***) different popular varieties compared with Indica.

Table 1. Productivity of cotton fibre of different hirsute varieties grown in the villages of Tamil Nadu (TN), India (Data are mean of four villages)

	Indica	MCU 5	MCU5 VT	Surabhi	Mean	SEM
Yield of seed cotton/kg/ha	2246	2020	2100	1973	2084	59.80

Table 2. Quality of cotton fibre of different hirsute varieties grown in the villages of TN. (Data are mean of four villages)

	Indica	MCU 5	MCU5 VT	Surabhi	Mean	SEM
Ginning (%)	34.70	36.00	32.67	34.00	34.34	0.69
Lint index (g)	5.92	5.60	5.40	5.80	5.68	0.11
Seed index (g)	10.97	10.50	10.70	10.50	10.66	0.11
2.5% Span length (mm)	34.27	33.40	33.50	23.50	31.16	2.56
Strength (g/tex)	23.02	24.40	22.10	22.70	23.05	0.49
Micronaire (ug/in)	3.83	3.6	3.7	3.6	3.7	0.05

Table 3. Degree of polymerization of fibres of different cotton varieties grown in the village farms

	Indica	MCU5	MCU5V T	Surabhi	Suvin*	Mean	SEM
Degree of polymerization	3926	3229	3360	2490	2727	2946.40	286.33
Cuprammonium fluidity at 20°C poise	0.88	1.01	2.79	2.39	1.81	1.77	0.37

*Sample of the lint of Suvin (*Gossypium barbadense*) was provided by CICR, Regl. Station, Coimbatore for testing.

higher initial DP results in better strength of processed fabric (Sujata Saxena, pers. commun., 2018). The DP of fibres of Indica was 3926, which is 18–39% higher than that of other varieties, including the *G. barbadense* variety Suvin that is grown in parts of Southern India (Table 3). The higher initial DP indicates that Indica, besides contributing much to lustre shows better dyeing capability[5] and strength of the fibres; gives better strength to processed fabric and is better suited for the textile industries than some other popular varieties.

The present study suggests that the short-statured cotton varieties like Indica, which have open canopy and fruit-bearing branches are capable of growing further in the event of falling of the reproductive parts due to insect bites or physiological changes appear to be better suited for global warming conditions[6]. Such varieties can cause least disturbance to the agro-ecosystem under the global warming situations[7–9].

1. Divya, P. S., *Natl. J. Adv. Res*., 2017, **3**, 60–65.
2. FAO, Fertilizer use by the crops in India; http://www.fao.org/docrep/009/a0257e/A0257E01.htm
3. Md. Wasim Aktar, Sengupta, D. and Chowdhury, A., *Interdiscip. Toxicol.*, 2009, **2**, 1–12.
4. Sundaramurthy, V. T., World Cotton Research Conference-3. Cape Town, South Africa, 2003, pp. 607–612.
5. Yang, Y. and Li, S., *Text. Chem. Color*., 1995, **27**, 29–33.
6. Sundaramurthy, V. T., *Indian Text. J*., 1996, **106**, 86–89.
7. Sundaramurthy, V. T., *Int. J. Bio-resour. Stress Manage.*, 2017, **8**, 593–600.
8. Sundaramurthy, V. T., *Cotton Statistics News*, 2017, **3**, 2017.
9. Zimniowska and Kozlowski, World Cotton Research Conference-3, Cape Town, South Africa, 2003, pp. 1645–1649.

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