

## NDLH 2051-1: a high-yield, sucking pest-tolerant cultivar of cotton

Bana Venkata Ravi Prakash Reddy<sup>1\*</sup>, Kalapati Mohan Vishnuvardhan<sup>1</sup>,  
D Lakshmi Kalyani<sup>1</sup>, T Raghavendra<sup>1</sup> and Yettapu Rama Reddy<sup>1</sup>

**Abstract:** *NDLH 2051-1 has a mean seed cotton yield potential of 1590 kg ha<sup>-1</sup> and has been singled out for commercial cultivation in the south and central zones of India by the Regional Agricultural Research Station, Nandyal, India. This cultivar represents an essential contribution to sustainable cotton production in India.*

**Keywords:** *Gossypium hirsutum, seed cotton yield, sucking pest tolerance*

### INTRODUCTION

Cotton is a crop grown to provide raw material to the textile industry. It is cultivated on approximately 3% of the world's arable land (Mubarik et al. 2020). India, China, the USA, Brazil, and Pakistan are leading cotton-producing countries. Global cotton production was 24.2 m tons in 2021 (ICAC 2021). In India, from 2020 to 2021, 371 lakh bales of seed cotton were produced from 129.57 lakh ha for productivity of 487 kg ha<sup>-1</sup> (AICRP on Cotton 2020/21). Cotton productivity has increased from around 300 kg ha<sup>-1</sup> in 2002/03 to near 500 kg ha<sup>-1</sup> currently. Nevertheless, this productivity remains among the lowest world wide. The global demand for cotton products is expected to increase 102% from 2000 to 2030 (Rahman and Zafar 2018), likely because arable land is decreasing, water supplies are declining, and the impact of global climate change on production is uncertain.

India is striving to improve productivity by implementing high-density planting systems and adopting pest protection measures (Kumar et al. 2020). Approximately 65% of the cotton area is in rainfed regions, primarily in India's central and southern zones. Drought restricts cotton plant growth and fiber development by reducing the leaf water potential, cell expansion, and carbohydrate metabolism (Khan et al. 2018). In addition, the cotton crop is affected by sucking pests such as jassids, thrips, whiteflies, aphids, and bollworms. In particular, the pink bollworm is responsible for a considerable reduction in the value of cotton (Vonzun et al. 2019). In India, cotton is affected by diseases such as bacterial leaf blight, myrothecium leaf spot, Alternaria leaf spot, and gray mildew (Monga and Sain 2020). Problems associated with changing rainfall patterns and temperatures during the crop growth period, the emergence of new pests and diseases, and resistance of pests to insecticidal measures are significant issues for varietal/hybrid improvement.


The cotton breeding program was established in 1906 at the Regional Agricultural Research Station, Nandyal, India, to develop cotton cultivars

Crop Breeding and Applied Biotechnology  
22(2): e41802225, 2022  
Brazilian Society of Plant Breeding.  
Printed in Brazil  
<http://dx.doi.org/10.1590/1984-70332022v22n2c15>



**\*Corresponding author:**

E-mail: [bvrpreddy@gmail.com](mailto:bvrpreddy@gmail.com)

 ORCID: 0000-0003-2601-5350

**Received:** 26 February 2022

**Accepted:** 10 May 2022

**Published:** 25 May 2022

<sup>1</sup> Acharya NG Ranga Agricultural University,  
Guntur, 522034, India

adaptable to the rainfed agricultural system. The program focuses on yield, fiber quality, and biotic and abiotic stress tolerance ability. The variety NDLH 2005-4 (Nandyal Hirsutum 2005-4) was developed with a mean seed cotton yield potential of (1380 kg ha<sup>-1</sup>) and sucking pest tolerance with mean jassid injury grade (2.2), jassids/3 leaves (8.1), white flies/3 leaves (12.2), and aphids/3 leaves (48.7). To improve productivity, it is essential to develop cultivars with more significant yield potential, better fiber traits, and higher pest and disease tolerance than the existing varieties. Considering the importance of production and productivity of cotton crop in India under rainfed farming, the present study was undertaken to develop a cultivar with high-yield potential, superior fiber traits, and biotic and abiotic stress tolerance suitable for rainfed conditions in India. We report a new variety, NDLH 2051-1 (Nandyal Hirsutum 2051-1), that possesses high mean seed cotton yield, high-quality fiber traits, and sucking pest tolerance to jassids, whiteflies, thrips, and aphids. This cultivar represents a fundamental contribution to cotton production in India's central and southern zones.

## BREEDING METHOD

NDLH 2051-1 (Nandyal Hirsutum 2051-1) arose from a cross involving two genotypes, HAG-823 (Hagari 823) as female and HYPS-152 (Hirsutum selection 152) as male, followed by the pedigree method of selection at the Regional Agricultural Research Station, Nandyal, India. The parents involved in the development of NDLH 2051-1 have several notable traits. For example, HAG-823 is a high yielder, and HYPS-152 has a boll weight of more than 5.0 g (Balakrishna et al. 2018). The seeds from the F<sub>1</sub> cross were sown and gave rise to a substantial F<sub>2</sub> population. Selection in the F<sub>2</sub> generation began with traits such as single plant seed cotton yield, boll size, staple length, bundle strength, and sucking pest tolerance. The selected F<sub>2</sub> plants gave rise to F<sub>3</sub> families, which formed the F<sub>4</sub> plants. The seeds of the F<sub>4</sub> selected plants formed the F<sub>5</sub> generation. The individual plant selection was carried out in the F<sub>3</sub>, F<sub>4</sub>, and F<sub>5</sub> generations based on yield, fiber, and pest and disease tolerance traits. The seeds of the F<sub>5</sub> selected plants formed the F<sub>6</sub> generation trial (i.e., the observational varietal trial in 2015–2016).

The preliminary varietal trial and advanced varietal trials of genotype NDLH 2051-1 were conducted in 2016–2017 and 2017–2018, respectively, and were evaluated in randomized block design for agronomic traits including earliness, plant height, number of monopodia, number of sympodia, bolls plant<sup>-1</sup>, bolls m<sup>-2</sup>, boll weight, seed cotton yield, ginning percentage, lint yield, lint index, seed index, and halo length at Regional Agricultural Research Station, Nandyal, India. Between 2017–2018 and 2019–2020, the genotype was evaluated in Minikit trials and All India Coordinated Cotton Improvement Project trials at various rainfed locations in India. The agronomic evaluation of NDLH 2051-1 was completed in 2020–2021 in rainfed regions of India and showed high seed cotton yield, sucking pest tolerance, and uniformity with suitability for rainfed conditions in the southern and central zones of India. Based on the performance of the variety in multilocation trials, the variety was identified by the Varietal Identification Committee for the southern and central zones of India on 9<sup>th</sup> April 2021, notified by The Gazette of India, Extraordinary (Part II-SEC.3(ii)) S.No.8 on 3 January 2022 for commercial cultivation, and will be available to farmers for the 2022/2023 growing season.

**Table 1.** Distinguishing characteristics of the variety NDLH 2051-1 as per the DUS guidelines

Plant character	Description and code (score) according to DUS Guidelines
Leaf: Color	Green (2)
Leaf: Hairiness	Medium (5)
Leaf: Nectaries	Present (9)
Leaf: Shape	Normal (1)
Plant: Stem hairiness	Medium (5)
Plant: Growth habit	Spreading (7)
Bract: Type	Normal (3)
Flower: Petal color	Yellow (2)
Flower: Petal spot	Absent (1)
Flower: Stigma	Exerted (5)
Flower: Pollen color	Cream (2)
Boll: Color	Green (3)
Boll: Shape	Ovate (5)
Boll: Surface	Smooth (1)
Boll: Prominence of tip	Pointed (9)
Boll: Weight of seed cotton/boll (g)	Small (3)
Seed: Fuzz	Medium (5)
Seed: Fuzz color	White (1)
Seed: Index (100 seed weight) (g)	Medium (5)
Ginning percentage	High (7)
Fiber: Color	White (1)
Fiber: Length (2.5% span length) (mm)	Long (7)
Fiber: Strength (g/tex)	Strong (7)
Fiber: Fineness (Micronaire)	Medium (5)
Fiber: Uniformity	Good (7)
Fiber: Maturity (%)	Good (7)

DUS – Distinctness, Uniformity, and Stability ([https://www.cicr.org.in/pdf/dus\\_test\\_manual.pdf](https://www.cicr.org.in/pdf/dus_test_manual.pdf)), a Training manual on DUS test in cotton with reference to PPV & FR legislation, 2001. The values in parenthesis indicate the notes (1 to 9) used to describe the state of each character for digital data processing, and these notes are given against the states of each characteristic.

## TRAITS AND PERFORMANCE

The descriptive traits NDLH 2051-1 based on DUS guidelines are displayed in Table 1. NDLH 2051-1 is a medium-type cultivar with a spreading growth habit. Its plant height ranges from 100 to 110 cm. NDLH 2051-1 is a medium maturing variety that entails approximately 160 days from seed to seed. Leaves have nectarines, medium hairiness, and are normal shaped. The stem is hairy. Bract type is normal. Flower petal and pollen colors are yellow and creamy, respectively. The petal spot is absent in the flower, and the stigma is exerted. The boll surface is smooth with an ovate shape and pointed tip. Both fuzz and lint colors are white. The fiber has long staple length with solid strength, good uniformity, and maturity percentage.

The descriptive statistics, analysis of variance, and least significance difference test were performed using the Statistical Tool for Agricultural Research (STAR) 2.1.0 software, according to Reddy et al. (2020). The mean seed cotton yield of variety NDLH 2051-1 was 1465 kg ha<sup>-1</sup> and 1715 kg/ha considering three years of testing over the central and southern zones, respectively (Table 2). The mean yield of the new variety is 4 and 18% higher in the central zone and 42 and 33% higher in the southern zone compared to local and zonal checks, respectively. The mean lint yields of the variety are 520 kg ha<sup>-1</sup> and 623 kg ha<sup>-1</sup> in the central and southern zones, respectively. The fiber trait, mean 2.5% span length of NDLH 2051-1 was 27.9 mm and 28.1 mm in the central and southern zones, respectively (Table 3). The bundle strength of the variety was 28.2 g tex<sup>-1</sup> and 25.9 g tex<sup>-1</sup> in central zone centers and 27.5 g tex<sup>-1</sup> and 26.3 g tex<sup>-1</sup> in southern zone centers based on a full spinning test (Table 4).

During the period of testing (2017/2018 to 2019/2020), the variety NDLH 2051-1 recorded mean jassid injury grades of 2.0 and 1.8, jassids/3 leaves of 7.2 and 4.2, white flies/3 leaves of 10.5 and 0.79, thrips/3 leaves of 42.8 and 0.8 and aphids/3 leaves of 73.6, and 5.0 in the central and southern zones, respectively (Table 5). The variety NDLH 2051-1

**Table 2.** Average seed cotton yield (kg ha<sup>-1</sup>), average lint yield (kg ha<sup>-1</sup>), mean ginning outturn (%), and mean bolls per plant of variety NDLH 2051-1 compared to local check (LC) and zonal check (ZC) in AIC trials

Varieties	Seed cotton yield (kg ha <sup>-1</sup> )				Lint yield (kg ha <sup>-1</sup> )				Ginning out turn (%)				Bolls per plant			
	17/18	18/19	19/20	Mean	17/18	18/19	19/20	Mean	17/18	18/19	19/20	Mean	17/18	18/19	19/20	Mean
Central zone (Bhanswara, Indore, Akola, Nanded and Nagpur)																
NDLH 2051-1	1114	1831	1450	1465a	410	655	495	520a	36.7	35.8	33.7	35.4	19.3a	22.9a	24.5b	22.2ab
LC	926	1745	1535	1402a	343	597	516	485ab	37.1	34.2	33.7	35.0	17.9a	24.0a	27.9a	23.3a
ZC	870	1392	1476	1246b	309	509	510	443b	35.8	36.6	34.4	35.6	17.1a	18.4b	25.3ab	20.3b
South zone (Dharwad, Nandyal and Perambalur)																
NDLH 2051-1	920a	2252a	1973a	1715a	338a	860a	670a	623a	35.5a	38.3a	34.2a	36.0a	8.5a	23.6a	17.3a	16.5a
LC	365b	1558b	1712b	1212b	120b	532b	577ab	410b	33.1b	33.6c	33.7a	33.5b	7.6a	19.0b	16.8a	14.5b
ZC	817a	1533b	1531b	1294b	286a	558b	527b	457b	34.2b	36.2b	34.2a	34.9a	8.6a	17.6b	15.2b	13.8b

The local checks used were NDLH 1755 and Wagad Kalyan in the southern and central zones, respectively. The zonal checks used were NDLH 1938 and NH 615 in the southern and central zones, respectively. Means with the same letter in the column are not significantly different by t test.

**Table 3.** Mean boll weight (g), mean 2.5% span length (mm), mean micronaire (μg inch<sup>-1</sup>), and mean bundle strength (g tex<sup>-1</sup>) of variety NDLH 2051-1 compared to local check (LC) and zonal check (ZC) in AIC trials

Varieties	Boll weight (g)				2.5% span length (mm)				Micronaire (μg inch <sup>-1</sup> )				Bundle strength (g tex <sup>-1</sup> )			
	17/18	18/19	19/20	Mean	17/18	18/19	19/20	Mean	17/18	18/19	19/20	Mean	17/18	18/19	19/20	Mean
Central zone (Bhanswara, Indore, Akola, Nanded and Nagpur)																
NDLH 2051-1	3.1ab	4.2a	3.5a	3.6a	27.8	27.5	28.3	27.9	3.9	4.5	4.4	4.3a	26.6	27.0	27.5	27.0
LC	3.2a	3.9b	3.0b	3.4ab	27.3	26.9	27.3	27.2	3.8	4.7	4.3	4.3a	27.1	27.6	27.6	27.4
ZC	2.9b	3.6c	3.3a	3.3b	27.0	28.6	28.7	28.1	3.9	3.9	3.9	3.9b	27.4	26.5	26.9	26.9
South zone (Dharwad, Nandyal and Perambalur)																
NDLH 2051-1	4.2a	4.1a	4.5a	4.3a	28.8	27.1	28.3	28.1a	4.0	4.4	4.9	4.4	28.6a	25.7a	27.0b	27.1ab
LC	3.5b	4.1a	4.1b	3.9b	28.9	27.4	28.1	28.1a	3.9	4.6	5.1	4.5	28.3a	26.3a	29.8a	28.1a
ZC	3.5b	4.3a	4.3ab	4.0b	27.8	26.8	26.5	27.0b	4.1	4.4	4.9	4.5	28.3a	24.5b	25.4c	26.1b

The local checks used were NDLH 1755 and Wagad Kalyan in the southern and central zones, respectively. The zonal checks used were NDLH 1938 and NH 615 in the southern and central zones, respectively. Means with the same letter in the column are not significantly different by t test.

recorded more substantial sucking pest tolerance for jassids, thrips, whiteflies, and aphids than local and zonal checks in India's central and southern zones. The use of pest-tolerant varieties reduces the indiscriminate use of chemical pesticides, toxic effects, and environmental pollution. Regarding reactions to significant diseases, the variety showed on par reaction with local and zonal checks for bacterial leaf blight, myrothecium leaf spot, Alternaria leaf spot, and gray mildew in the central and southern zones (Table 6).

**Table 4.** Fiber quality characteristics of variety NDH 2051-1 based on full spinning test

Zone	Location	UHML (mm)	UI	Mic	Str (g tex <sup>-1</sup> )	E (%)	Count 1	CSP1	Count 2	CSP2
Central zone	Nagpur	27.4	85	4.5	28.2	5.6	20s	2503	30s	2085
	Nanded	25.9	81	4.2	25.9	5.6	30s	2163	40s	1939
South zone	Dharwad	27.5	81	3.8	27.5	5.5	30s	2199	40s	1851
	Nandyal	26.5	82	4.2	26.3	5.5	30s	2617	40s	1781

**Table 5.** The reaction of variety NDH 2051-1 to different sucking pests compared to local check (LC) and zonal check (ZC) in AIC trials

Varieties	Jassid injury grade				Jassid/3 leaves				White flies/3 leaves			
	17/18	18/19	19/20	Mean	17/18	18/19	19/20	Mean	17/18	18/19	19/20	Mean
Central zone (Bhanswara, Indore, Akola, Nanded and Nagpur)												
NDLH 2051-1	2.0b	2.3a	2.3ab	2.0b	6.0b	9.9a	5.9a	7.2a	9.7c	11.7a	10.4a	10.5a
LC	4.0a	2.0ab	2.6a	2.8a	11.3a	7.1b	5.8a	8.0a	13.6b	7.1c	11.4a	10.7a
ZC	4.0a	1.3b	1.6b	2.3ab	11.7a	7.0b	4.7a	7.8a	16.7a	9.4b	10.4a	12.1b
South zone (Dharwad, Nandyal and Perambalur)												
NDLH 2051-1	2.5b	1.6a	1.3b	1.8b	6.7b	2.9a	3.1b	4.2b	0.5b	0.5b	1.39ab	0.79b
LC	1.5c	1.6a	1.3b	1.4c	4.2c	3.0a	2.6c	3.2c	1.0a	0.75a	1.57a	1.1a
ZC	3.0a	1.6a	2.0a	2.2a	9.6a	2.4b	4.6a	5.5a	0.2c	0.8a	1.15b	0.71b
Varieties	Thrips/3 leaves				Aphids/3 leaves							
	17/18	18/19	19/20	Mean	17/18	18/19	19/20	Mean				
Central zone (Bhanswara, Indore, Akola, Nanded and Nagpur)												
NDLH 2051-1	-	79.7	5.9	42.8ab	-	131b	16.3a	73.6b				
LC	-	82.5	11.4	46.9a	-	153a	16.2a	84.6a				
ZC	-	70.8	5.1	37.9b	-	157.5a	16.7a	87.1a				
South zone (Dharwad, Nandyal and Perambalur)												
NDLH 2051-1	0.4b	1.65a	0.47a	0.8a	-	9.4c	0.61ab	5.0b				
LC	1.1a	1.5a	0.45a	1.0a	-	11.4b	0.41b	6.0b				
ZC	0.0c	1.2b	0.6a	0.9a	-	15.0a	1.45a	8.2a				

The local checks used were NDH 1755 and Wagad Kalyan in the southern and central zones, respectively. The zonal checks used were NDH 1938 and NH 615 in the southern and central zones, respectively. Means with the same letter in the column are not significantly different by t test.

**Table 6.** The reaction of variety NDH 2051-1 to different major diseases compared to local check (LC) and zonal check (ZC) in AIC trials

Varieties	Bacterial leaf blight				Myrothecium leaf spot				Alternaria leaf spot				Gray mildew			
	17/18	18/19	19/20	Mean	17/18	18/19	19/20	Mean	17/18	18/19	19/20	Mean	17/18	18/19	19/20	Mean
Central zone (Bhanswara, Indore, Akola, Nanded and Nagpur)																
NDLH 2051-1	-	1.3	1.3	1.3	-	1.0	1.0	1.0	-	2.0a	1.5a	1.7a	-	1.0	2.0	1.5a
LC	-	1.0	1.3	1.1	-	1.0	1.0	1.0	-	1.0b	1.0b	1.0c	-	0.5	2.0	1.2b
ZC	-	1.3	1.3	1.3	-	1.0	1.0	1.0	-	1.0b	1.5a	1.25b	-	0.5	1.5	1.0c
South zone (Dharwad, Nandyal and Perambalur)																
Varieties	Bacterial leaf blight				Alternaria leaf spot				Gray mildew				Rust			
	17/18	18/19	19/20	Mean	17/18	18/19	19/20	Mean	17/18	18/19	19/20	Mean	17/18	18/19	19/20	Mean
NDLH 2051-1	1.0b	1.0b	4.0a	2.0b	4.0	4.0	4.0	4.0	4.0	2.0	4.0	3.3	-	4.0	-	4.0
LC	2.0a	2.0a	4.0a	2.6a	4.0	4.0	4.0	4.0	4.0	2.0	4.0	3.3	-	4.0	-	4.0
ZC	1.0b	2.0a	3.0b	2.0b	4.0	4.0	4.0	4.0	4.0	2.0	4.0	3.3	-	4.0	-	4.0

The local checks used were NDH 1755 and Wagad Kalyan in the southern and central zones, respectively. The zonal checks used were NDH 1938 and NH 615 in the southern and central zones, respectively. Means with the same letter in the column are not significantly different by t test.

## MOLECULAR BACKGROUND

To obtain the genetic profile of the new variety, DNA fingerprinting of NDLH 2051-1 with control samples was carried out using 16 simple sequence repeat markers at the Division of Genomic Resources, National Bureau of Plant Genetic Resources, New Delhi, India. A comparison of the NDLH 2051-1 with other control samples showed that the primers were BNL-2709, BNL-3008, MUCS-400, MUCS-152, NAU-980, NAU-3995, JESPR-197, and JESPR-152 were polymorphic and could be used for the identification of the variety.

## SEED PRODUCTION AND AVAILABILITY

NDLH 2051-1 was identified with national identity number IC638617 by the Division of Germplasm Conservation, National Bureau of Plant Genetic Resources, New Delhi, India. The breeder seeds of the variety are produced by the Acharya N G Ranga Agricultural University, Regional Agricultural Research Station, Nandyal, Andhra Pradesh, India, and will be available for commercial crop cultivation for the 2022/2023 growing season.

## ACKNOWLEDGMENTS

The authors thank the Acharya N G Ranga Agricultural University, Andhra Pradesh, All India Coordinated Improvement Project on Cotton, Coimbatore and Central Institute of Cotton Research, Nagpur, India for support and guidance in the development of variety.

## REFERENCES

- AICRP on Cotton (2020-21) Project coordinators report. Available at <[http://aiccip.cicr.org.in/main\\_aiccip\\_reports.html](http://aiccip.cicr.org.in/main_aiccip_reports.html)>. Accessed on February 21, 2022.
- Balakrishna B, Reddy CV, Reddy KVS, Satish Y and Reddy KB (2018) Identification of donor parents containing favourable alleles for improving target American cotton hybrid (NA 1325 × L 604). *Indian Journal of Agricultural Sciences* 88: 504-508.
- ICAC – International Cotton Advisory Committee (2021) Expected revival in world cotton production in 2021/22 season. Available at <<http://www.icac.org>>. Accessed on February 21, 2022.
- Khan A, Pan X, Najeeb U, Tan DKY, Fahad S, Zahoor R and Luo H (2018) Coping with drought: stress and adaptive mechanisms, and management through cultural and molecular alternatives in cotton as vital constituents for plant stress resilience and fitness. *Biological Research* 51: 47
- Kumar M, Premalatha N, Mahalingam L, Sakthivel N, Senguttuvan K and Latha P (2020) High density planting system of cotton in India: Status and breeding strategies. Intechopen. Available at <<http://dx.doi.org/10.5772/intechopen.94905>>. Accessed on February 21, 2022.
- Monga D and Sain SK (2020) Integrated disease management in cotton. ICAR-CICR, Regional Station, Coimbatore-641003 Tamil Nadu, p. 38. (AICRP on Cotton-Technical Bulletin 1/2020).
- Mubarak MS, Ma C, Majeed S, Du X and Azhar MT (2020) Revamping of cotton breeding programs for efficient use of genetic resources under changing climate. *Agronomy* 10: 1190
- Rahman MU and Zafar Y (2018) Past, present and future trends in cotton breeding. Intechopen. Available at <<http://dx.doi.org/10.5772/intechopen.69672>>. Accessed on February 21, 2022.
- Reddy VRP, Das S, Dikshit HK, Mishra GP, Aski M, Meena SK, Singh A, Pandey R, Singh MP, Tripathi K, Gore PG, Priti, Bhagat TK, Kumar S, Nair R and Sharma TR (2020) Genome wide association analysis for phosphorus use efficiency traits in mungbean (*Vigna radiata* L) using genotyping by sequencing approach. *Frontiers in Plant Science* 11: 537766
- Vonzun S, Messmer MM, Boller T, Shrivastava Y, Patil SS and Riar A (2019) Extent of bollworm and sucking pest damage on modern and traditional cotton species and potential for breeding in organic cotton. *Sustainability* 11: 6353.