GNCH-1: a high yielding, wilt and leafhopper resistant castor hybrid suitable for Gujarat

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ABSTRACT

GNCH-1 a high yielding, wilt and leafhopper resistant castor hybrid was developed by Pulses and Castor Research Station, Navsari Agricultural University, Navsari, Gujarat and released by Central Sub-Committee on Crop Standards, Notification and Release (CVRC) of Variety for Agricultural Crops in 2017 for commercial cultivation under irrigated situation of Gujarat State, India. The hybrid GNCH-1 was developed by crossing a pistillate line SKP-84 with a male line DCS-94. On an average of 18 trials conducted for five years in south and middle Gujarat, the hybrid GNCH-1 recorded a seed yield of 2545 kg/ha which is 13.8, 35.9 and 31.0 per cent higher yield over the checks GCH-7, DCH-519 and DCH-177, respectively. The hybrid had long primary spike (64.8 cm), more numbers of capsules per primary spike (78.4), matures within 110-112 days and medium height (70-80 cm) which makes it suitable for easy harvesting. The oil content of the hybrid GNCH-1 (47.0 to 48.0 %) revealed that it is at par with the checks. The hybrid screened for wilt at national wilt sick plots showed resistance reactions (< 20%) to wilt. GNCH-1 screened against leafhopper using infester row method during 2014-17 showed resistant reaction to leafhopper (hopper burn grade 0 to 1 on 0-4 scale). The hybrid demonstrated in the farmers fields for two years (2016-18) showed higher seed yield than the existing cultivars. Due to plasticity for sowing time, this new hybrid is a suitable choice for the farmers of south and middle Gujarat under irrigated condition during late kharif and rabi seasons and paddy based cropping system.

Keywords: Castor, GNCH-1, Hybrid, Late *kharif,* Leafhopper, *Rabi,* Resistance, Wilt

Castor (*Ricinus communis* L.) is an industrially important non-edible oilseed crop belonging to the family Euphorbiaceae. Castor oil has diversified uses and has great value of foreign trade. In India, castor is mainly grown in Gujarat, Rajasthan, Andhra Pradesh and Telangana states, accounting for about 95 per cent of the area and production. Gujarat ranks first in area, production and productivity with 5.41 lakh hectares, 11.21 lakh tonnes and 2072 kg/ha, respectively during 2016-17 (DES, 2018). Gujarat state alone produces 80 per cent of the total castor of our country from about 67 per cent of the area with the highest productivity. Though northern and middle Gujarat region is the traditional castor growing belt, castor is also gaining popularity in south Gujarat due to high fertile soil, irrigation facility, suitable climatic condition and diversity of terrain.

Due to heavy rainfall and heavy black soil having poor drainage capacity, castor cultivation in *kharif* season is not possible in south Gujarat conditions. The other released hybrids grow very tall due to prolonged moisture retention in the soil. Therefore, farmers prefer late *kharif* or *rabi* season for castor cultivation in vacant field after *kharif* paddy. Further, the *kharif* paddy area in south Gujarat is more than 2.0 lakh hectares and castor will be the best alternative after *kharif* paddy. So, there was a need to develop suitable varieties/hybrids of castor for *rabi* season to meet the desired production levels. Wilt (*Fusarium oxysporum* f. sp. *ricini*) is the major constraint in castor cultivation in Gujarat area under irrigated conditions. Fusarium wilt occurs in castor plant at any time throughout growing period. The extent of seed yield loss ranges from 39 to 77 per cent depending upon the stage of the crop (Pushpavathi, 1995). Losses in yield were realized in all cultivated castor hybrids in Gujarat (Dange *et al.,* 1997) and as high as 85 per cent wilt incidence has been reported under North Gujarat conditions (Dange, 2003). Sucking insect pests *viz.,* leafhopper (*Empoasca flavescens*), whitefly (*Trialeurodes ricini*) and thrips (*Retithrips syriacus* and *Scirtothrips dorsalis*) are considered as serious concern to late *kharif* and *rabi* castor crops and yield losses to the tune of 12.4 to 15 per cent was reported from Gujarat (Patel *et al.,* 1999; Lakshminarayana and Duraimurugan, 2014; Patel *et al.,* 2015). Host plant resistance is an economical and environment-friendly method of insect pest and disease management. Resistance to insect pests and diseases should be given as much emphasis as yield to identify new varieties and hybrids for cultivation by the farmers (Sharma and Ortiz, 2002; Anjani *et al.,* 2014; Kavani *et al.,* 2016). Thus, castor hybrid GNCH-1 was developed which exhibited desirable features *viz*., high yielding, resistance to wilt and leafhopper and suitable for cultivation

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in south and middle-Gujarat for late-*kharif* and *rabi* season. The hybrid was released by CVRC for Agricultural Crops during 2017 for commercial cultivation under irrigated situation of Gujarat. The present paper deals with the development and evaluation of hybrid in multilocation trials.

MATERIALS AND METHODS

GNCH-1 was developed by crossing of wilt resistant pistillate line SKP-84 obtained from Castor and Mustard Research Station, SDAU, SK Nagar and male line DCS-94 from ICAR-Indian Institute of Oilseeds Research (ICAR-IIOR), Hyderabad during 2010-11 at Pulses and Castor Research Station, Navsari Agricultural University, Gujarat. The hybrid, GNCH-1 (NCH-1) was evaluated in preliminary station trial at Navsari during 2011-12 in RBD along with check hybrids to record various ancillary and yield contributing characters. Based on the best performance in the preliminary station trial, GNCH-1 was included in Initial Varietal Hybrid Trial under All India Coordinated Research Project on Castor (AICRP on Castor) during 2012-13. Due to its best performance, it was further evaluated in Advanced Varietal and Hybrid Trials during 2013-14 and 2014-15 at multi locations along with check hybrids. The hybrid was also evaluated for its yield potential along with check hybrids under State trials *viz*., Preliminary Varietal Hybrid Trial (PVHT), Small Scale Varietal Hybrid Trial (SSVHT) and Large Scale Hybrid Trial (LHT) during 2013-14 to 2015-16. Further the hybrid GNCH-1 was demonstrated in 5 adaptive trials and 10 FLDs on farmers' fields during 2016-18. The recommended packages of practices were followed while conducting the trials to raise a healthy crop. Yield potential and ancillary observations with respect to yield traits of GNCH-1 and the checks were recorded as described by AICRP (Castor) guidelines. The yield data was analyzed according to Panse and Sukhatme (1985).

Screening for wilt resistance of the hybrid was carried out during 2012-13 to 2014-15, along with wilt susceptible (JI-35) and resistant (48-1) checks and hybrid checks (DCH-177, DCH-519, GCH-7) under permanent wilt sick plots maintained at ICAR-IIOR, Hyderabad and Castor and Mustard Research Station, SK Nagar, Gujarat. The wilt incidence recorded as total plants and wilt infected plants at 30 days interval upto 150 and 180 days at ICAR-IIOR, Hyderabad and SK Nagar, respectively and per cent was calculated. Reaction of experimental material against wilt was categorized as per the scale given by Lakshminarayana and Raoof (2006). Based on the wilt incidence, the genotypes found free from wilt disease (0% wilt disease) were regarded as highly resistant. The cultivars with wilt incidence up to 20% were classified as resistant and those with more than 20% wilt incidence were considered as susceptible.

Screening of the hybrid and its parents against major insect pests was carried out using infester row method (Anjani *et al.,* 2018) along with susceptible checks (DPC-9, DCS-9 and DCS-107), resistant checks (M-574) and existing hybrid checks (DCH-519, DCH-177, GCH-7) during 2014-17 at three locations (ICAR-IIOR, Hyderabad; RARS, Palem and TCRS, Yethapur). Observations on incidence of sucking pests (leafhopper, thrips), defoliators (semilooper and spodoptera) and capsule borer on five randomly selected plants were recorded. The data on leafhopper were recorded on three leaves, representing top, middle and lower canopy of each entry and the respective hopper burn was recorded on 0-4 scale (Duraimurugan and Alivelu, 2017). Population of thrips was observed on the top most tender but not fully opened leaf and also on immature spikes. The absolute population of adult whitefly was recorded from fully developed top leaf. Absolute larval population of defoliators from each plant was recorded. Number of capsules damaged by the capsule borer was recorded from five randomly selected plants and then per cent capsule damage was worked out (Lakshminarayana, 2005; Duraimurugan and Lakshminarayana, 2016). The data was subjected to statistical analysis using AGRES statistical software. Following ANOVA, differences between datasets were determined using least significant difference at P = 0.05.

RESULTS AND DISCUSSION

The yield performance of castor hybrid GNCH-1(NCH-1) along with three check hybrids (GCH-7, DCH-519 and DCH-177) in the Initial Varietal Hybrid Trial (IVHT) and Advanced Varietal and Hybrid Trials (AVHT) under AICRP on Castor at multi locations during 2012-13 to 2014-15 is presented in Table 1. The hybrid GNCH-1 exhibited higher mean seed yield of 2848 kg/ha from 26 trials as compared with state and national check hybrids *viz*., GCH-7 (2679 kg/ha), DCH-519 (2564 kg/ha) and DCH-177 (2621 kg/ha) with an economic heterosis 6.3 per cent, 11.1 per cent and 8.6 per cent, respectively (Table 1). The hybrid was found promising in Preliminary Evaluation Trial (PET) conducted at Pulses and Castor Research Station, Navsari during 2011-12, where the hybrid out yielded the check GCH-7 by 40.5 per cent (Table 2). Hence, it was nominated in AICRP and state trials, simultaneously. During 2012-13, two trials conducted at Navsari centre *viz.,* IVHT and Pre Release Hybrid trial-I, the hybrid GNCH-1 produced 20.0 and 10.1 per cent more seed yield as compared to the check GCH-7.

In Pre Release Hybrid Trial-II and AVHT-I trials conducted during late *kharif*/*rabi* 2013-14, the hybrid surpassed the check GCH-7 by 5.8 and 20.3 per cent, respectively at Navsari centre (Table 2). In 2014-15, the hybrid was tested under various trials in South Gujarat i.e. Navsari (3), Vyara (1) and Achhalia (1). In AVHT-II,

SSVHT (state) and LHT (station) conducted at Navsari, GNCH-1 showed 24.5, 24.1 and 18.0 per cent increase over the state check GCH-7. In rest of the two locations i.e. Vyara and Achhalia in LHT trial the hybrid out yielded the check by 17.1 and 25.2 per cent, respectively (Table 2). In multiplications trial (LHT) 2015-16 at three locations, GNCH-1 surpassed the state and national checks viz., GCH-7, DCH-519 and DCH-177 by 11.8, 16.9 and 13.5 per cent, respectively. Thus, on an average of 18 trials conducted for five years in south and middle Gujarat, the hybrid showed 13.8, 35.9 and 31.0 per cent higher yield over the state check, GCH-7 and national checks DCH-519 and DCH-177, respectively. The hybrid had long primary spike (64.8 cm), more numbers of capsules per primary spike (78.4), matures within 110-112 days and medium height (70-80 cm) which makes it suitable for easy harvesting. A representative picture of the plants of the parents and the hybrid is given in Fig. 1. The data of oil content of the hybrid GNCH-1 (47.0-48.0 %) revealed that it is at par with the checks. GNCH-1 was tested in Adaptive trials and Tribal Sub-plan during 2016-17 and 2017-18 at Navsari, Surat, Bharuch, Vadodara and Narmada districts in farmers fields where it recorded overall 13.0 and 7.43 per cent increased yield over local check, respectively (Table 3). Castor is found more suitable and economical under south Gujarat due to its yield potential, low cost of cultivation and more economic returns (Patel, 2011). Local variety of castor grown in rice fallows on residual moisture is a common practice in south Gujarat. The crop survives without any additional inputs like nutrients, water and adoption of other cultural practices. Consequently, the average yield realized by the farmers is as low as 4 to 5 q/ha and most of the hybrids commonly grown by the farmers were developed for *kharif* season planting. Therefore, to over come these problems, GNCH-1 was developed suitable for late *kharif* and *rabi* seasons under irrigated areas of south and middle Gujarat. This hybrid gave significant higher yield than existing cultivars and has the potential to be replaced with the local cultivars for irrigated castor areas of south and middle Gujarat especially in *rabi* season.

Table 1 Yield (kg/ha) performance of NCH-1 (GNCH-1) at all AICRP (Castor) centers under irrigated condition (2012-2015)

Year	Trials	Centres	All India Irrigated (AICRP on Castor)					% Increase over		
			NCH-1	GCH-7	DCH-519	DCH-177	(P=0.05)	GCH-7	DCH-519	DCH-177
First 2012-13	IVHT	PRE-Rel-I Navsari	2471 (1)	2244(8)	1634(18)	1906(13)	612	10.1	51.2*	29.6
		Navsari	2321(1)	1934(3)	1586(5)	1323(12)	417	20.0	46.3*	75.4*
		Derol	2924(1)	2329(5)	2053(10)	2320(6)	514	25.5*	42.4*	26.0*
		Anand	3764(3)	3807(2)	2234(14)	2572(11)	308	-1.1	68.5*	46.3*
		Bawal	2734(3)	897(16)	1425(10)	2901(2)	204	204.8*	91.9*	-5.8
		Junagadh	2645(6)	2922(2)	2848(3)	2270(15)	576	-9.5	-7.1	16.5
		Mandor	3061(13)	4859(1)	2999(14)	3214(12)	840	-37	2.1	-4.8
		Talod	2824(2)	2748(3)	1924(8)	1681(11)	397	2.8	46.8*	68*
		Mean	**2843**	**2718**	**2088**	**2273**	**-**	**4.6**	**36.2**	**25.1**
Second 2013-14	AVHT-I	PRE-Rel-II Navsari	1815(1)	1715(6)	1144 (13)	1357 (8)	415	5.8	58.7*	33.8*
		Navsari	2426(1)	2016(7)	1795 (12)	1926 (10)	227	20.3*	35.2*	26*
		Bawal	2946(3)	2020(9)	2783 (4)	3105 (2)	309	45.8*	5.9	-5.1
		Junagadh	2409(5)	2707(2)	2698 (3)	2005 8)	478	-11.0	-10.7	20.1
		Mandor	4028(3)	3910(5)	4193 (1)	4001 (4)	273	3.0	-3.9	0.7
		SK nagar	3641(4)	3444(7)	3084 (7)	2897 (8)	NS	5.7	18.1	25.7
		Talod	3754(12)	3944(10)	4478 (8)	4753 (5)	880	-4.8	-16.2	-21.0
		Anand	2501(5)	2125(8)	2994 (1)	2833 (3)	364	17.7*	-16.5	-11.7
		Kanpur	890(4)	738(9)	700 (10)	906 (2)	100	20.6*	27.1*	-1.8
		Mean	**2712**	**2513**	**2652**	**2643**	**-**	**7.9**	**2.3**	**2.6**
Third 2014-15	AVHT-II	Navsari	2651(1)	2129(3)	2137(1)	2007(4)	325	24.5*	24.1*	32.1*
		Anand	3941(2)	3460(3)	2654(8)	3039(5)	488	13.9	48.5*	29.7*
		Bawal	2936(3)	2518(5)	3118(2)	3639(1)	356	16.6*	-5.8	-19.3
		Bhatapara	1647(4)	1586(7)	1695(2)	1611(6)	NS	3.8	-2.8	2.2
		Junagadh	3599(7)	4349(2)	4228(3)	3791(4)	397	-17.2	-14.9	-5.1
		Kanpur	1405(2)	1123(5)	1055(9)	1516(1)	256	25.1*	33.2*	-7.3
		Mandor	3216(4)	2970(6)	3245(3)	3347(2)	293	8.3	-0.9	-3.9
		SK nagar	4830(3)	4061(7)	4734(4)	4886(2)	622	18.9*	2.0	-1.1
		Talod	2669(7)	3092(5)	3234(3)	2550(8)	527	-13.7	-17.5	4.7
		Mean	**2988**	**2810**	**2900**	**2932**	**-**	**6.4**	**3.0**	**1.9**
		Over all mean (26)	**2848**	**2679**	**2564**	**2621**	**-**	**6.3**	**11.1**	**8.6**
		Frequency in top three groups	15/26	10/26	10/26	8/26	-	-	-	-

*Significant at 5%; Figures in parenthesis indicate ranking

The male parent DCS-94 was tested under sick plot conditions at IIOR, Hyderabad during 2013-14 and it showed resistant reaction of 10.1 per cent. The hybrid GNCH-1 was screened for wilt at national wilt sick plots where, it showed resistance reaction in IVHT, AVHT-I and II trials conducted at Castor and Mustard Research Station, SK Nagar and IIOR, Hyderabad from 2012-2015 (Table 4). The wilt incidence ranges from 9.3 to 19.6 per cent in GNCH-1 with an average of 14.2 per cent under sick plot of S.K. Nagar, Gujarat. The wilt incidence was 0.0 to 17.6 per cent in GCH-7 with an average of 10.8 per cent and disease incidence varied from 11.5 to 44 per cent with an average of 32.9 per cent in DCH-519. In resistant check 48-1 and susceptible check JI-35 recorded an average of 2.3 and 100 per cent wilt incidence, respectively. At sick plot of IIOR, Hyderabad the wilt incidence in GNCH-1 varied from 14 to 30.9 per cent with an average of 19.9 per cent, while disease ranged from 23.8 to 31.9 per cent in GCH-7 with an average wilt of 27.2 per cent. Wilt disease was 1.2 per cent in 48-1, resistant check however 100 per cent wilt recorded in susceptible check, JI-35 (Table 4). Wilt caused by *Fusarium oxysporum* f. sp. *ricini* is a devastating disease of castor. Chemical control of castor wilt is not effective and economical as the pathogen is soil and seed-borne in nature and difficult to eradicate. The use of wilt resistant cultivars is the best and cost effective method (Anjani *et al.,* 2014). GNCH-1 found resistant to wilt (wilt incidence up to 20%) under sick plots at SK Nagar and IIOR, Hyderabad. This hybrid has the potential to be replaced with the previously approved cultivars with resistance to wilt disease and higher yield parameters.

Table 2 Yield (kg/ha) performance of GNCH-1 in South and Middle Gujarat (2012-2016)

Year	Trial	Centre	Middle & South Gujarat					% Increase over		
			GNCH-1	GCH-7	DCH-519	DCH-177	(P=0.05)	GCH-7	DCH-519	DCH-177
2011-12	PET	Navsari	4549	3237	-	-	926	40.5*	-	-
2012-13	IVHT (AICRP)	Navsari	2321	1934	1586	1323	417	20.0	46.3*	75.4*
		Derol	2924	2329	2053	2320	514	25.5*	42.4*	26.0*
		Anand	3764	3807	2234	2572	308	-1.1	68.5*	46.3*
	Pre-Rel-I (ACIRP)	Navsari	2471	2244	1634	1906	612	10.1	51.2*	29.6*
		Mean	**3206**	**2710**	**1877**	**2030**	**-**	**11.3**	**52.9**	**41.4**
	Pre-Rel-II (ACIRP)	Navsari	1815	1715	1144	1357	415	5.8	58.7*	33.8*
2013-14	AVHT-I (AICRP)	Navsari	2426	2016	1795	1926	227	20.3*	35.2*	26.0*
		Anand	2501	2125	2994	2833	364	17.7*	-16.5	-11.7
	PVHT (State)	Anand	2331	3188	-	-	534	-26.9	-	-
		Mean	**2268**	**2261**	**1978**	**2039**	**-**	**0.3**	**13.6**	**10.2**
	AVHT-II	Navsari	2651	2129	2136	2007	325	24.5*	24.1*	32.1*
		Anand	3941	3460	2654	3039	488	13.9	48.5*	29.7*
	SSVHT (State)	Navsari	2789	2247	-	-	404	24.1*	-	-
2014-15	LHT(MLT)	Navsari	2271	1924	1490	1693	372	18.0*	52.4*	34.1*
		Vyara	1783	1523	949	792	280	17.1	87.9*	125.1*
		Achhalia	1477	1180	971	707	268	25.2*	52.1*	108.9*
		Mean	**2485**	**2077**	**1640**	**1648**	**-**	**19.7**	**47.8**	**47.2**
2015-16	LHT(MLT)	Navsari	2350	2095	1889	2050	304	12.2	24.4*	14.6
		Vyara	1825	1615	1624	1553	262	13.0	12.4	17.5*
		Achhalia	1626	1481	1451	1507	148	9.8	12.1*	7.9
		Mean	**1934**	**1730**	**1655**	**1703**	**-**	**11.8**	**16.9**	**13.5**
		Overall mean (18)	**2545**	**2236**	**-**	**-**	**-**	**13.8**	**-**	**-**
		Over all mean (15)	**2410**	**-**	**1774**	**1839**	**-**	**-**	**35.9**	**31.0**

*Significant at 5% level

The hybrid GNCH-1 (NCH-1) and its parental lines were screened against major insect pests of castor for three years (2014-15 to 2016-17) and the reaction of the hybrid and checks to major insect pests is presented in Table 4 and 5. GNCH-1 found resistant to leafhopper consistently for three years with hopper burn grade of 0 to 1 (on 0-4 scale) with lower leafhopper populations in the range of 0.5 to 14.0/3 leaves/plant, while the susceptible check (DPC-9) recorded hopper burn grade of 2 to 4 with higher leafhopper populations of 14.3 to 129.1/3 leaves/plant (Table 4). The

parental lines of GNCH-1 *viz.,* SKP-84 and DCS-94 were also exhibited resistance reaction to leafhopper with hopper burn grade of 0 to 2. The hybrid GNCH-1 was found promising against thrips and harboured low infestation of thrips (3.6 to 66.0 thrips/spike) as compared to susceptible checks *viz*., DCS-9 and DPC-9 (0.7 to 116.0 thrips/spike). No significant difference was observed in the population of whitefly among the hybrid and susceptible check (M-574). The reaction of GNCH-1 to defoliators *viz*., semilooper and spodoptera (0.0 to 14.5 larvae/plat) was found similar to the hybrid checks *viz*., DCH-519, DCH-177 and GCH-7 (0.0 to 13.0 larvae/plant). GNCH-1 recorded lower capsule borer damage (upto 24.3%) as compared to susceptible check, DCS-9 (upto 43.4%) (Table 5). One of the most limiting factors in the production of castor is the high incidence of insect-pests (Duraimurugan and Lakshminarayana, 2016). The problem of sucking pests *viz*., leafhopper, whitefly and thrips was reported to be high in Gujarat and Rajasthan (Patel *et al.,* 1999; Patel *et al.*, 2015). Resistant cultivars can be the simplest, practical, effective and economical method of insect pest control. The hybrid GNCH-1 found resistant to leafhopper provide an inherent control of the pest without any expenses or environmental pollution problems.

Table 3 Yield (kg/ha) performance of GNCH-1 in farmers fields at Gujarat (2016-2018)

Name of the village	Tahasil/Block	District	No. of demonstrations	Area in ha	Mean Yield kg/ha		
					GNCH-1	Farmers hybrid	Yield increase (%) over farmers hybrid
Year 2016-17 (Adaptive trial on GNCH-1)							
Arthan	Olpad	Surat	1	0.36	3380	2960	14.19
Bhatgam	Olpad	Surat	1	0.4	3860	3350	15.22
Navanagar	valiya	Bharuch	1	0.5	3580	3250	10.15
Satisana	Sinor	Vadodara	1	0.5	4120	3690	11.65
Kolasana	Maroli	Navsari	3	1	3120	2740	13.87
Mean					**3612**	**3198**	**13.0**
Year 2017-18 (FLD under TSP castor scheme)							
Almavadi	Dediapada	Narmada	10	4	2760	2370	16.46
Nivalda	Dediapada	Narmada	3	1.2	2640	2420	9.09
Khabji	Dediapada	Narmada	2	0.8	3000	2730	9.89
Ghankhetar	Dediapada	Narmada	3	1.2	2750	2470	11.34
Navagam	Dediapada	Narmada	1	0.4	2660	2400	10.83
Khurdi	Dediapada	Narmada	1	0.4	2260	2100	7.62
Gopaliya	Dediapada	Narmada	1	0.4	2100	1960	7.14
Khokaraumar	Dediapada	Narmada	1	0.4	2450	2280	7.46
Songam	Garudeshwar	Narmada	4	1.6	2390	2200	8.64
Sajanpura	Garudeshwar	Narmada	4	1.6	2500	2350	6.38
Mean					**2340**	**2178**	**7.43**

Table 4 Reaction of NCH-1 (GNCH-1) to wilt disease

Inoculation	Year of testing	Centre	Proposed hybrid	Check 1	Check 2	Check 3	Resistant check	Susceptible check
		IIOR, Hyderabad	NCH-1 (GNCH-1)	GCH-7	DCH-519	DCH-177	48-1	JI-35
Artificial (sick plot)	1st year (2012-13)		14.0	31.9	27.4	22.2	0.0	100
	2nd year (2013-14)		30.9	23.8	19.3	32.2	0.0	100
	3rd year (2014-15)		14.9	25.9	18.8	43.2	3.8	100
Fusarium wilt incidence (%)		Mean	19.9	27.2	21.8	32.5	1.2	100
		SK Nagar						
	1st year (2012-13)		13.7	17.6	44.0	34.6	6.8	100
	2nd year (2013-14)		9.3	0.0	43.3	57.7	0.0	100
	3rd year (2014-15)		19.6	14.8	11.5	36.4	0.0	100
		Mean	14.2	10.8	32.9	42.9	2.3	100

Scale: 0-20 % resistant, >20% susceptible

Table 5 Reaction of GNCH-1 (NCH-1) and its parents to sucking pests of castor (2014-15 to 2016-17)

Genotype	2014-15					2015-16						2016-17				
	Leafhopper				Thrips (No./ spike)	Leafhopper				Thrips (No./ spike)	Whitefly (No. of adults/leaf)	Leafhopper				Thrips (No./ spike)
	Yethapur		IIOR, Hyderabad			Yethapur		IIOR, Hyderabad				Yethapur		IIOR, Hyderabad		
	No./ 3 leaves /plant	Hopper burn (0-4 grade)#	No./ 3 leaves /plant	Hopper burn (0-4 grade)	Yethapur	No./ 3 leaves /plant	Hopper burn (0-4 grade)	No./ 3 leaves /plant	Hopper burn (0-4 grade)	Yethapur	Yethapur	No./ 3 leaves /plant	Hopper burn (0-4 grade)	No./ 3 leaves /plant	Hopper burn (0-4 grade)	Yethapur
NCH-1	5.2	0	8.5	1	3.6	15.3	1	14.0	1	65.0	4.0	0.5	0	3.9	1	13.8
SKP-84	5.0	0	16.6	2	7.1	5.6	0	12.0	1	107.0	2.0	5.5	0	5.5	1	1.5
DCS-94	5.3	0	9.8	1	6.9	14.3	1	13.1	1	38.0	2.0	7.7	0	6.3	1	2.2
DPC-9©	14.3	3	129.1	4	1.8	18.3	2	88.7	4	106.0	7.0	55.0	4	68.7	4	0.7
DCS-9©	5.7	1	19.7	3	5.9	2.3	0	43.4	3	66.0	5.0	0.0	0	24.1	3	6.7
DCS-107©	5.7	1	16.0	4	4.6	13.0	1	47.5	4	112.0	9.0	21.2	2	35.6	4	1.8
M-574©	-	-	-	-	-	12.3	0	11.2	1	66.0	4.0	0.0	0	8.2	0	4.2
GCH-7©	-	-	-	-	-	12.6	1	16.3	1	72.0	2.0	8.8	0	5.8	1	5.7
DCH-519©	4.7	0	8.3	1	2.4	9.3	0	17.0	1	70.0	2.0	0.0	0	8.9	1	0.7
DCH-177©	20.0	3	68.3	4	3.3	11.0	1	70.1	4	115.0	5.0	15.2	1	46.4	4	3.0
CD (P=0.05)	1.52	-	21.7	0.9	1.21	1.9	-			17.1	0.7	5.10	-	4.72	-	2.09

© Checks (Susceptible checks - DPC-9, DCS-9, DCS-107; Resistant checks - M-574; Hybrid checks - GCH-7, DCH-519; DCH-177)
#Hopper burn grade: 0 - No injury (Highly Resistant), 1- up to 10% (Resistant), 2 - 11 to 25% (Moderately Resistant), 3 - 26 to 50% (Susceptible), 4 - above 50% (Highly Susceptible)

Table 6 Reaction of GNCH-1 (NCH-1) and its parents to defoliators and capsule borer (2014-15 to 2016-17)

Genotype	2014-15						2015-16						2016-17	
	Defoliators (Larvae/plant)				Capsule damage (%)		Defoliators (Larvae/plant)				Capsule damage (%)		Defoliators (Larvae/plant)	
	Palem		Yethapur		Yethapur	IIOR, Hyderabad	Palem		Yethapur		Yethapur	IIOR, Hyderabad	Palem	
	Semi-looper	*Spodoptera litura*	Semi-looper	*Spodoptera litura*			Semi-looper	*Spodoptera litura*	Semi-looper	*Spodoptera litura*			Semi-looper	*Spodoptera litura*
NCH-1	0.9	0.7	1.6	1.4	6.4(14.6)	14.7(22.5)	0.9	0.9	0.0	0.0	5.4	24.3 (29.5)	14.5	0.9
SKP-84	1.3	0.3	1.6	1.0	7.4(15.7)	17.5(24.6)	0.9	0.4	0.0	0.2	0.0	42.1 (40.4)	10.1	0.5
DCS-94	0.8	0.3	1.3	0.6	7.5(15.9)	12.2(20.5)	1.2	0.4	0.0	0.2	3.2	40.6 (39.5)	15.2	1.0
DPC-9©	2.5	1.6	0.6	0.0	5.6(13.7)	10.5(18.9)	2.1	5.0	0.2	10.3	1.1	18.6 (25.6)	7.8	0.2
DCS-9©	1.4	0.9	1.0	0.1	5.4(13.5)	40.6(39.5)	1.1	1.0	0.0	0.0	1.3	43.4 (41.2)	8.3	0.4
DCS-107©	1.3	0.7	2.1	0.6	6.8(15.1)	11.5(19.8)	5.4	0.8	0.0	0.0	3.5	28.4 (32.1)	12.3	0.3
M-574©	-	-	-	-	-	-	3.4	0.8	0.0	0.0	10.7	29.8 (33.0)	9.2	1.1
GCH-7©	-	-	-	-	-	-	1.1	0.5	0.0	0.0	5.8	22.2 (27.9)	10.1	0.4
DCH-519©	0.9	0.4	1.1	0.6	9.3(17.7)	9.4 (17.9)	6.5	0.9	0.3	0.0	0.0	27.9 (31.7)	13.0	0.5
DCH-177©	2.6	1.6	1.1	0.1	8.0(16.5)	7.6 (16.1)	2.8	4.3	0.2	0.0	0.0	13.6 (21.6)	11.3	1.2
CD (P=0.05)	0.20	0.21	0.57	0.03	0.97	6.06	0.49	0.36	0.52	13.85	2.68	9.74	4.8	-

©- Check; #Figures in parentheses are arc sine values

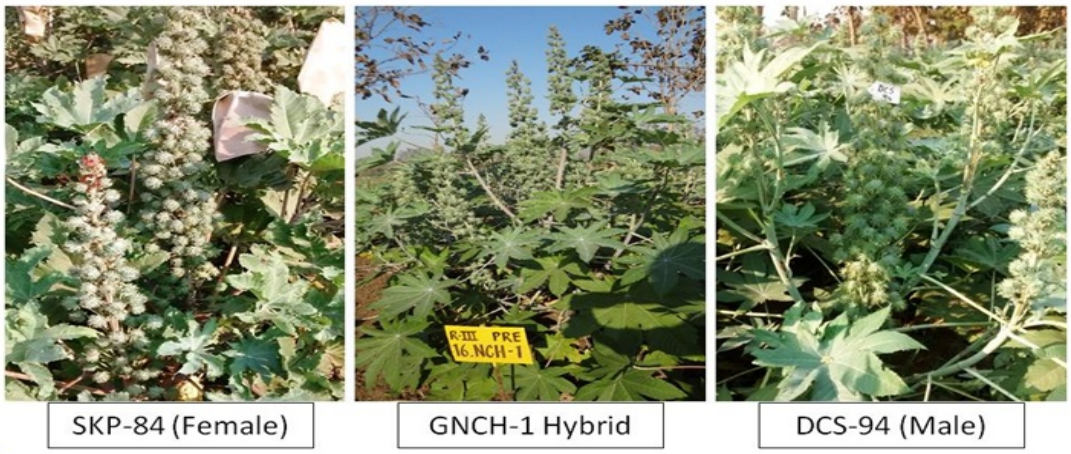

Fig. 1. Representative plants of the hybrid, GNCH-1 and its parents, SKP-84 and DCS-94, at physiological maturity stage

In nutshell, the hybrid GNCH-1 (Gujarat Navsari Castor Hybrid-1) has high yield potential coupled with wilt and leafhopper resistance, plasticity for sowing time makes this hybrid a suitable choice for the farmers of south and middle Gujarat under irrigated condition during late *kharif* and *rabi* seasons. Thus, hybrid GNCH-1 was released by CVRC for Agricultural Crops, and notified vide S.O 2805 (E) dated 25/08/2017 for commercial cultivation under irrigated situation of Gujarat.

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REFERENCES

Anjani K, Raoof M A, Santha Lakshmi Prasad M, Duraimurugan P, Lucose C, Praduman Y, Prasad R D, Jawahar Lal J and Sarada C 2018. Trait-specific accessions in global castor (*Ricinus communis* L.) germplasm core set for utilization in castor improvement. *Industrial Crops and Products,* **112**: 766-774.

Anjani K, Raoof M A and Desai A G 2014. Evaluation of world castor (*Ricinus communis* L.) germplasms for resistance to Fusarium wilt (*Fusarium oxysporum* f. sp. *ricini*). *European Journal of Plant Pathology*, **139**: 567-578.

Dange S R S 2003. Wilt of castor-An overview. *Journal of Mycology and Plant Pathology*, **33**: 333-339.

Dange S R S, Desai A G and Patel D B 1997. Management of wilt of castor in Gujarat State in India. *In: Proceedings of International Conference on Integrated Plant Disease Management for Sustainable Agriculture*, 10-15 November 1997, IARI, New Delhi, India, pp. 107.

DES 2018. *Directorate of Economics and Statistics.* Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India.

Duraimurugan P and Alivelu K 2017. Field efficacy of newer insecticides against sucking insect pests in castor. *Indian Journal of Plant Protection*, **45**(3): 246-250.

Duraimurugan P and Lakshminarayana M 2016. Studies on relative fitness and off-season activity of castor capsule borer, *Conogethes punctiferalis* Guenee (Lepidoptera : Crambidae). *Journal of Oilseeds Research*, **33**(4): 221-225.

Kavani R H, Vachhani J H, Madariya R B, Jadeja S R and Dobariya K L 2016. Combining ability for seed yield and its components in castor (*Ricinus communis* L.). *Journal of Oilseeds Research*, **33**(1): 22-25.

Lakshminarayana M and Duraimurugan P 2014. Assessment of avoidable yield losses due to insect pests in castor (*Ricinus communis* L.). *Journal of Oilseeds Research*, **31**: 140-144.

Lakshminarayana M 2005. Studies on antixenosis in castor (*Ricinus communis* L.) against major insect pests. *Indian Journal of Plant Protection*, **33**, 216-219.

Lakshminarayana M and Raoof M A 2006. *Crop Protection,* Research Achievements in Castor, All India Co-ordinated Research Project on Castor, Directorate of Oilseeds Research, Hyderabad, India, pp. 49-80.

Panse V G and Sukhatme P V 1985. *Statistical Methods for Agricultural Workers.* Indian Council of Agricultural Research, New Delhi.

Patel A J 2011. Effect of weed management in rabi castor (*Ricinus communis* L.) under south Gujarat conditions. M. Sc. (Agri) Thesis, Navsari Agricultural University, Navsari, Gujarat state, pp. 141.

Patel B C, Patel P S, Trivedi J B and Patel S A 2015. Population dynamics of sucking pest complex of castor (*Ricinus communis* L.). *International Journal of Agriculture Sciences*, **7**(8): 596-600.

Patel I S, Patel G M and Pathak H C 1999. *Insect Pests of Castor and their management*, Main Castor Research Station, Gujarat Agricultural University, Sardar Krushinagar, Gujarat, pp.17.

Pushpavathi B 1995. Role of *Fusarium oxysporium* f. sp. *ricini* (Wr.) Gordon in castor wilt complex. M.Sc. (Ag) thesis, Andhra Pradesh Agricultural University, Rajendranagar, Hyderabad. pp. 107.

Sharma H C and Ortiz R. 2002. Host plant resistance to insects: An eco-friendly approach for pest management and environment conservation. *Journal of Environmental Biology*, **23**:111-135.