ICH-66, a new high yielding and biotic stress-resistant castor hybrid suitable for rainfed conditions of Peninsular India

A J PRABAKARAN, C LAVANYA, T MANJUNATHA, G BALAKISHAN, P DURAIMURUGAN, M SANTHA LAKSHMI PRASAD, S SENTHILVEL, G SURESH, P LAKSHMAMMA, R D PRASAD, K T RAMYA, PRADUMAN YADAV, J JAWAHARLAL, C SARADA, D K PATEL[1], C J PATEL[1], MUKESH PATEL[2], P SUNIL KUMAR, K S VARAPRASAD AND A VISHNUVARDHAN REDDY

ICAR-Indian Institute of Oilseeds Research, Rajendranagar, Hyderabad-500 030, Telangana

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ABSTRACT

ICH-66, a new castor hybrid has been developed at ICAR-Indian Institute of Oilseeds Research (ICAR-IIOR), Hyderabad, India and identified by Combined Varietal Identification Committee of Oilseed Crops during 2018 for release under rainfed areas of Peninsular India in *kharif* season. The hybrid was developed using the parents SKP-84 and ICS-164 and tested at station trials of ICAR-IIOR during 2013-14 and 2014-15. Considering its superiority over checks, it was evaluated in MLTs of AICRP (Castor) during 2015-16, 2016-17 and 2017-18 along with hybrid checks DCH-519 and DCH-177. ICH-66 recorded a mean seed yield of 1566 kg/ha which is 14.9 and 18.3 per cent higher than the checks DCH-519 (1324 kg/ha) and DCH-177 (1363 kg/ha) respectively. It also had a mean oil content of 48.6 per cent, which is 2.2 and 3.4 per cent higher than the check DCH-177 (47.0% oil content) and DCH-519 (47.6% oil content), respectively. The hybrid had a longer effective primary spike length (45 cm) and better 100-seed weight (29.0 g) under rainfed conditions compared with checks DCH-177 (39 cm and 27.3 g) and DCH-519 (44.8 cm and 26.4 g). The hybrid is medium in maturity duration (100-130 days for primary spike maturity), non-lodging and non-shattering type. The hybrid showed resistance against Fusarium wilt and Macrophomina root rot. It was also found resistant to leafhopper with hopper burn grade of 0 to 1 (on 0-4 scale) at multilocations in all the years of screening. Owing to its superiority for seed yield, oil content and biotic-stress resistance, it will be suitable for rainfed areas of Telangana, Andhra Pradesh, Karnataka, Tamil Nadu and Odisha states in India.

Keywords: Castor, Hybrid, ICH-66, Leafhopper, Peninsular India, Resistance, Root rot, Wilt

Castor (*Ricinus communis* L.) is an important non-edible oilseed crop in India. Its seed oil has vast and varied industrial applications such as lubricants, cosmetics, surfactants, surface coatings, plasticizers, nylon, medicines etc. (Ogunniyi, 2006; Suresh, 2009). India ranks first in global castor area (8.07 lakh hectares), production (13.76 lakh tonnes) and productivity (1704 kg/ha) and holds a premier position with 80 per cent of worlds castor oil exports (DES, 2017). In India, castor is cultivated under two contrasting environments *viz.,* irrigated conditions with high productivity (1338 to 2072 kg/ha) in Gujarat and Rajasthan; and rainfed conditions under low input application with low productivity (312 to 631 kg/ha) in Andhra Pradesh, Telangana, Tamil Nadu, Karnataka and Odisha (DES, 2017). Among the 22 public sector bred hybrids, GCH-4 released in the year 1993 for all castor growing regions of the country was popular in rainfed areas of Southern India due to its wide adaptability and higher hundred seed weight. Among other hybrids, DCH-177 released in 2000 for rainfed regions of Southern states and parts of Maharashtra and Madhya Pradesh and DCH-519 released in 2006 for all castor growing regions of the country are popularly grown by the farmers in southern India (Lavanya and Solanki, 2010; Lavanya and Varaprasad, 2012; Sujatha *et al.,* 2017). However, GCH-4 is highly susceptible to Fusarium wilt and DCH-177 has low hundred seed weight (26 to 27 g) coupled with susceptibility to leafhopper due to its single bloom nature. Though, DCH-519 is high yielding and wilt resistant under both irrigated and rainfed conditions across India, its susceptibility to gray mold disease during cyclone weather condition has been a major constraint in peninsular India. There is always a need to develop improved varieties/hybrids with high yield and good quality characteristics (Naeem-ud-Din *et al.,* 2012). Success of heterosis breeding is dependent on identification of wilt resistant parental lines with good combining ability and evaluation of hybrids with good agronomic management. Thus, castor hybrid ICH-66 has been developed which exhibited desirable features *viz*., high yielding, high seed weight and oil content coupled with resistance to Fusarium wilt, Macrophomina root rot and leafhopper. The hybrid has been identified by Combined Varietal Identification Committee meeting of Oilseed Crops during 2018 for rainfed areas of Peninsular India. In this paper, the development of hybrid and its unique features are discussed.

[1]AICRP (Castor), Main Castor & Mustard Research Station, SDAU, SK Nagar-385 506, Gujarat; [2]AICRP (Castor), Regional Research Station, Anand Agricultural University, Anand-388 110, Gujarat

MATERIALS AND METHODS

The new hybrid ICH-66 was developed at ICAR-Indian Institute of Oilseeds Research, Hyderabad, using the parents, SKP-84 and ICS-164 in *kharif*, 2012. SKP-84 (female), a pistillate line was developed through pedigree method of selection by hybridizing SKP-1 and VP-1 at SDAU. ICS-164, a monoecious inbred (male) was developed through pedigree method of selection from the cross 48-1 x RG-1582. This hybrid along with 135 new hybrids generated at ICAR-IIOR was evaluated at ICAR-IIOR, Hyderabad (under rainfed) and Anand, Gujarat (irrigated conditions) during *kharif* 2013. The genotypes were sown in two rows in an augmented design along with two checks *viz.,* DCH-177, DCH-519 at Hyderabad and DCH-519 and GCH-7 at Anand. Recommended agronomical practices were followed to raise a good crop. Observations were recorded on quantitative characters *viz.,* plant height upto primary spike (cm), days to 50% flowering, number of nodes to primary spike, total and effective spike length (cm), number of effective spikes per plant, pick wise seed yield (g/plant) and 100-seed weight (g). The data were analyzed for seed yield and yield components as per ARBD analysis of Federer (1961). Promising hybrids identified in the common hybrid trial were further re-evaluated in a replicated trial (RBD, 4 rows per entry) both under rainfed and irrigated conditions.

Based on its superiority over the best checks and wilt resistance, ICH-66 was included in the Initial Varietal and Hybrid Trial (IVHT) of All India Coordinated Research Project (AICRP) on Castor during 2015-16. Due to its good performance, it was further promoted to Advanced Varietal and Hybrid Trials (AVHT-I & II) during 2016-17 and 2017-18 at multi locations (Table 3) along with check hybrids. All the trials were conducted under rainfed conditions in Peninsular India. The recommended package of practices were followed while conducting the trials to raise a healthy crop. Yield potential and ancillary observations with respect to yield traits of ICH-66 and the checks were recorded as described by AICRP (Castor) guidelines. The oil content was estimated using a bench top pulsed low-resolution nuclear magnetic resonance analyser (Oxford-MQC-5, London, UK) according to the method of Yadav and Murthy (2016).

Reaction to biotic stresses (insect pests and diseases) were assessed during 2015-16 to 2017-18. Screening of the hybrid against major insect pests was carried using infester row technique (Anjani *et al.,* 2018) along with susceptible checks (DPC-9 and DCS-107) and existing hybrid checks (DCH-519, DCH-177, GCH-7) at three locations (Palem, Yethapur and S.K Nagar). Observations on incidence of sucking pests (leafhopper, thrips), defoliators (semilooper and spodoptera) and capsule borer were recorded from five randomly selected plants. 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 (Lakshminarayana, 2005). Population of thrips was observed on the top most tender but not fully opened leaf and also on immature spikes. 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 computed (Duraimurugan and Alivelu, 2017; Duraimurugan and Lakshminarayana, 2014).

Screening of the hybrid along with susceptible, resistant and hybrid checks for wilt resistance was carried out in permanent wilt sick plots maintained at ICAR-IIOR, Hyderabad, AICRP (Castor) centres at Palem, Telangana state and S.K. Nagar, Gujarat during 2015-16 to 2017-18. 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 which were found free from wilt disease (0% wilt disease) were scored 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. The hybrid was screened against gray mold disease at ICAR-IIOR, Hyderabad under artificial, glass house and natural conditions as described by Prasad and Kumaraswamy (2017). Screening for root rot resistance was carried out in a permanent root rot sick plot maintained at AICRP (Castor) centre, Junagadh during 2015-16 to 2017-18 along with resistant and susceptible checks. The experimental materials were categorized as per Mayee and Datar (1986).

RESULTS AND DISCUSSION

Among the 136 hybrids evaluated in Preliminary Hybrid Trial (PHT), under rainfed conditions at IIOR, Hyderabad, seed yield of 17 hybrids was better than the best check, DCH-177 (409 g/plant). The same set of hybrids when evaluated under irrigated conditions at Anand, ICH-32 with 57% significant increase over the best check GCH-7 (4102 kg/ha), followed by ICH-382, ICH-66 (47%), ICH-65 (41%), ICH-605 and ICH-851 with 30% significant increase over the national check, DCH-519 (3796 kg/ha) were promising (Table 1). Six hybrids, which were promising either in rainfed or irrigated conditions alone or both the conditions, were further re-evaluated in a replicated trial both under rainfed and irrigated conditions during 2014-15. Among the six hybrids, ICH-66 (15%) and ICH-68 (35%) with significant increase over the best check, GCH-7 (3188 kg/ha) were nominated as potential hybrids for evaluation in coordinated trials (Table 2). The comparative performance of castor hybrid, ICH-66 during three consecutive years (2015-16 to 2017-18) for mean seed yield (kg/ha) is presented in Table 3. In *kharif* evaluation, for three years, under rainfed conditions, ICH-66 recorded a weighted mean seed yield of 1566 kg/ha pooled over 20 trials, which is 18.3 and 14.9 per cent higher than the check hybrids, DCH-519 (1324 kg/ha) and DCH-177 (1363 kg/ha), respectively. The perusal of data obtained from 15 trials during *kharif* season under rainfed conditions revealed that the castor hybrid, ICH-66 had a mean oil content of 48.6 per cent which is 2.2 and 3.4 per cent higher than the checks, DCH-177 and DCH-519, respectively (Table 3). ICH-66 recorded a mean oil yield of 659 kg/ha over 15 rainfed locations which is 10 per cent higher than the check DCH-177 (599 kg/ha) and 19.3 per cent higher than the check DCH-519 (552 kg/ha) (Table 3).

The ancillary characters of ICH-66 along with check hybrids (DCH-519 and DCH-177) are presented in Table 4. The hybrid had medium crop duration (95 days for primary spike maturity), which was similar to DCH-519 (94.3 days) and DCH-177 (93.3 days). ICH-66 had longer effective primary spike length (45 cm) and better mean 100-seed weight (28.6 g) under rainfed conditions compared to checks DCH-177 (39.3 cm and 27.4 g) and DCH-519 (44.8 cm and 26.4g) respectively. Important agronomic and morphological characteristics of ICH-66 and its parents are presented in Table 5. Morphological features of ICH-66 include red stem colour, triple bloom, flat leaf, semi spiny capsules, long and loose spike, basal divergent branching, oval seed and chocolate seed coat colour. ICH-66 is similar to GCH-4 with red stem colour, triple bloom and semi spiny capsules (Fig. 1).

The major diseases limiting castor cultivation are gray mold, wilt and root rot. Wilt causes an yield loss of 20 to 50 per cent and gray mold disease causes an yield loss of 5 to 85 per cent in Andhra Pradesh, while wilt causes an yield loss of 20 to 60 per cent and root rot leads to an yield loss of 5 to 50 per cent in Gujarat. The extent of yield loss due to wilt depends on the stage at which plant wilts and ranged from 77 per cent at flowering to 39 per cent in later stages on secondary branches (Pushpawathi *et al.,* 1998). Lakshminarayana and Raoof (2006) reported reduction of 10 to 40 per cent in yield, 8 to14 per cent in seed weight and 1 to 2 per cent in seed oil content due to wilt infection. Host plant resistance is the cost effective approach to manage the wilt and root rot diseases. The screening techniques are well developed for wilt and root rot and resistant sources identified led to the development of resistant castor cultivars. Permanent wilt sick plots were developed at IIOR, Hyderabad; Palem, Telangana state and S.K. Nagar, Gujarat by growing and *in situ* incorporation of infected plant debris of highly susceptible variety. The inoculum was incorporated in wilt sick plots prior to sowing and inoculum load of at least 2×10^3 CFU/g of soil was maintained in wilt sick plots during the screening.

The parental line ICS-64 was screened under wilt sick plot conditions during 2014-15 and 2016-17 and the wilt incidence varied from 10 to 11.4 per cent with average of 10.7 per cent, which was on par with 48-1, the resistant check (10.2% wilt), while the JI-35, susceptible check (Table 8), showed 92.8 per cent wilt incidence. The new hybrid ICH-66 recorded wilt incidence ranging from 5.3 to 34.7 per cent with an average of 16.9 per cent under sick plot of IIOR, Hyderabad. This was on par with DCH-519 in which wilt ranged from 3 to 23.5 per cent with average of 15.2 per cent. Wilt incidence varied from 30.5 to 54.6 per cent with average of 40.2 per cent in DCH-177. At sick plot of S.K. Nagar, Gujarat, wilt incidence in ICH-66 varied from 1.9 to 27.3 per cent with an average of 15.7 per cent, while the disease incidence ranged from 5.5 to 15.6 per cent in DCH-519 with an average wilt of 9.4 per cent (Table 6). The wilt incidence ranged from 52.8 to 91.8 per cent in DCH-177. Wilt disease was not observed in 48-1 (resistant check), however 100 per cent wilt was recorded in JI-35 (susceptible check). The wilt incidence was moderate and varied from 30.3 to 33.9 per cent with average of 31.9 per cent in ICH-66 at sick plot of Palem, while average wilt incidence was 30.7 per cent in DCH-519. The disease ranged from 38.5 to 68.5 per cent with average of 52.1 per cent in DCH-177. The wilt incidence was 4.6 per cent and 95.8 per cent in 48-1 and JI-35, respectively (Table 6). The gray mold severity ranged from 35 to 70 per cent in ICH-66, while the severity was 55 to 81.3 per cent in DCH-519. The gray mold was 25 to 53.3 per cent in DCH-177 (Table 6).

The root rot incidence was lower (11.4 to 20% with average of 16.4%) in ICH-66 under sick plot conditions, compared to the checks, DCH-519 (0-34.6%; mean 17.9%) and DCH-177 (15-36.7%, mean 25%). In susceptible check GCH-4, the root rot incidence varied from 68.2 to 85.8 per cent with mean of 79 per cent while root rot was 7.4 to 24.5 per cent in JI-357, resistant check (Table 7).

The hybrid ICH-66 was screened against major insect pests of castor at three locations for three years along with susceptible checks (DPC-9 and DCS-107) and hybrid checks (DCH-519, DCH-177, GCH-7). ICH-66 showed resistant reaction to leafhopper with hopper burn grade of 0 to 1 on 0-4 scale across locations over years, while susceptible checks (DPC-9 and DCS-107) recorded hopper burn grade of 2 to 4. Hopper burn grade in hybrid checks *viz.*, DCH-519, DCH-177 and GCH-7 ranged from 0 to 2, 0 to 3 and 0 to 2, respectively (Table 8). During the three years of testing against thrips, ICH-66 recorded 3.7 to 32 thrips/spike and 0.6 to 2.4 thrips/tender most top leaf, while the population in susceptible check (DPC-9) and hybrid checks ranged from 3.6 to 32 thrips/spike and 0.7 to 2.4 thrips/tender most top leaf. The reaction of ICH-66 to defoliators *viz.,* semilooper and *spodoptera* (0.0 to 7.9 larvae/plant) was found similar to the checks (0.0 to 8.7 larvae/plant). Castor crop is attacked by a number of insect pests and the magnitude of insect pest problem is quite high in Southern India, where castor is grown mainly as rainfed crop, resulting in lower seed yields. Host-plant resistance is the most reliable, economical and eco-friendly measure to minimize the pests incidence and severity. In low value crops, other methods are often too expensive, development of varieties or hybrids resistant to insect pests can be an acceptable recommendation for the farmers. Plant waxes have the primary function of maintaining the water balance but they also interfere with insect-plant relationship either positively or negatively. In castor, double and triple blooms reported to harbour low population of leafhopper and thrips (Lakshminarayan and Duraimurugan, 2014). ICH-66, a triple bloom is found resistant to leafhopper compared to existing hybrid, DCH-177, which is susceptible to leafhopper due to its single bloom nature.

Table 1 Promising hybrids in Preliminary Hybrid Trial (2013-14) at Anand

Hybrids	Days to 50 % flowering	Plant height (cm)	Effective spike length (cm)	Number of effective spikes per plant	Number of capsules per primary	Seed yield (kg/ha)			
						Primary	Secondary	Tertiary	Total
ICH-605	58	76	59	13	87	1918	1574	1431	4923
ICH-382	67	126	75	18	76	678	1191	4147	6017
ICH-851	57	71	73	12	121	1172	1679	2080	4931
ICH-23	56	87	52	11	72	791	775	3382	4948
ICH-32	59	90	84	14	135	1269	1460	3729	6458
ICH-65	66	93	75	14	88	1175	1461	3136	5772
ICH-66	66	84	84	18	128	1715	604	3728	6047
DCH-519 ©	59	80	70	12	94	646	943	2207	3796
GCH-7 ©	61	81	66	16	81	561	830	2711	4102
Mean	58	79	63	13	84	711	766	1723	3200
CV (%)	6	12	9	16	14	25	34	24	13
CD (Trts vs Checks)	4.4	26	15	5.4	31	477	324	1124	1136

Table 2 Promising hybrids identified in Preliminary Hybrid Trial-II at Anand (2014-15)

Hybrids	Number of nodes to primary raceme	Plant height up to primary spike (cm)	Days to 50% flowering of primary spike	Days to maturity of primary spike	Effective primary spike length (cm)	No. of effective spikes/ plant	100 seed weight (g)	Oil content (%)	Total seed yield (kg/ha)
ICH- 66	17	54	60	125	50	8	33	46.7	3665
ICH-68	16	63	60	125	51	7	30	45.5	4297
GCH- 7	18	69	60	136	62	8	29	43.9	3188
Mean	17	63	58	131	62	8	29	44.4	2748
C.D (p=0.05)	2	11	3	2	11	1	2	2.0	553
CV%	8	11	3	1	11	12	5	2.78	12

Table 3 Comparative performance of ICH-66 for seed yield, oil content and oil yield in coordinated trials under rainfed conditions (*kharif*, 2015-16 to 2017-18)

Parameters	Year of testing	No. of trials/locations	ICH-66	DCH-519	DCH-177
Mean seed yield (kg/ha)	1st year (2015-16)	10	1562	1275	1263
	2nd year (2016-17)	6	1451	1350	1468
	3rd year (2017-18)	4	1748	1406	1457
	Weighted mean	-	1566	1324	1363
Percentage increase or decrease of ICH-66 over checks	1st year (2015-16)	-	-	22.5	23.7
	2nd year (2016-17)	-	-	7.5	-1.2
	3rd year (2017-18)	-	-	24.3	20.0
	Weighted mean	-	-	18.3	14.9

Table 3 (contd...)

Parameters	Year of testing	No. of trials/locations	ICH-66	PCH-519	DCH-177
Mean oil content (%)	1st year (2015-16)	7	49.4	47.3	47.4
	2nd year (2016-17)	4	49.5	47.4	48.2
	3rd year (2017-18)	4	46.4	46.1	47.3
	Weighted mean	-	48.6	47.0	47.6
Percentage increase or decrease of ICH-66 over checks	1st year (2015-16)	-	-	4.4	4.2
	2nd year (2016-17)	-	-	4.4	2.7
	3rd year (2017-18)	-	-	0.7	-1.9
	Weighted mean	-	-	3.4	2.2
Mean oil yield (kg/ha)	1st year (2015-16)	7	621	534	550
	2nd year (2016-17)	4	686	562	663
	3rd year (2017-18)	4	698	574	619
	Weighted mean	-	659	552	599
Percentage increase or decrease of ICH-66 over checks	1st year (2015-16)	-	-	16.2	12.7
	2nd year (2016-17)	-	-	22.1	3.4
	3rd year (2017-18)	-	-	21.7	12.8
	Weighted mean	-	-	19.3	10.0

Table 4 Ancillary characters of the hybrid, ICH-66 under rainfed conditions (*kharif*, 2015-16 to 2017-18)

Character	Year of testing	ICH-66	DCH-519	DCH-177
Days to 50% flowering of primary spike	2015-16	51	52	51
	2016-17	51	54	48
	2017-18	50	51	46
	Mean	51	52	48
Days to maturity of primary spike	2015-16	97	98	94
	2016-17	94	93	96
	2017-18	94	92	90
	Mean	95	94	93
Number of nodes to primary spike	2015-16	15	15	13
	2016-17	19	15	14
	2017-18	16	16	13
	Mean	17	15	13
Plant height up to primary spike (cm)	2015-16	102	101	88
	2016-17	112	108	91
	2017-18	109	128	92
	Mean	108	112	90
Effective length of primary spike (cm)	2015-16	46	45	39
	2016-17	41	39	40
	2017-18	49	51	39
	Mean	45	50	39
Number of capsules per primary spike	2015-16	55	50	46
	2016-17	59	57	54
	2017-18	68	61	50
	Mean	61	60	50
Number of effective spikes per plant	2015-16	5	4	4
	2016-17	4	5	4
	2017-18	6	6	6
	Mean	5	5	5
100-seed weight (g)	2015-16	29.5	26.4	26.6
	2016-17	28.8	26.5	27.4
	2017-18	27.6	26.4	28.1
	Mean	28.6	26.4	27.4

Fig. 1. Representative picture of spike at maturity and seeds of ICH-66

Table 5 Morphological features of the hybrid, ICH-66 and its parents

Characters	ICH-66	SKP-84 (Female)	ICS-164 (Male)
Hypocotyl : Anthocyanin pigmentation	Present	Present	Present
Leaf : Anthocyanin pigmentation of young emerging leaves	Present	Present	Present
Leaf : Waxi bloom on upper side	Present	Present	Absent
Leaf : Waxi bloom on lower side	Present	Present	Present
Stem : Waxi bloom	Present	Present	Present
Stem : Colour (after removal of bloom)	Red	Red	Red
Stem : Type of internodes	Elongated	Condensed	Elongated
Leaf : Length of 4th leaf from top (cm)	Medium	Medium	Medium
Plant : Time of 50% flowering of primary spike (days)	Medium	Medium	Medium
Stem : Number of nodes on main stem upto primary spike	Medium	High	Medium
Leaf : Shape	Flat	Deep cup	Flat
Leaf: Number of lobes	Many	Few	Many
Leaf: Lascination	Shallow	Shallow	Shallow
Petiole : Length (cm)	Medium	Medium	Medium
Petiole : Surface	Smooth	Smooth	Smooth
Inflorescence: Type of flowers on primary spike	Monoecious	Pistillate	Monoecious
Inflorescence: Spike shape	Conical	Conical	Conical
Inflorescence: Spike compactness	Loose	Semi compact	Loose
Inflorescence : Length of primary spike (cm)	Long	Long	Long
Capsule : Spininess	Semi-spiny	Dense	Non-spiny
Capsule: Length (cm) (central part of the spike)	Medium	Medium	Medium
Plant: Location of branches	Basal	Basal	Basal
Plant : Branching pattern	Divergent	Convergent	Divergent
Plant : Height up to the base of primary spike (cm)	Medium	Medium	Medium
Seed : Weight of 100 seeds (g)	Medium	Medium	Medium
Seed : Shape	Oval	Oval	Oval
Seed : Coat colour	Chocolate	Chocolate	Chocolate
Seed : Mottling	High	High	High
Seed : Caruncle	Small	Small	Small
Seed: Oil content (%)	High	High	High

Table 6 Reaction of ICH-66 against Fusarium wilt and gray rot diseases (2015-16 to 2017-18)

Year of testing	Centre	ICH-66	DCH-177	DCH-519	GCH-7	Resistant check 48-1	Susceptible check JI-35
Fusarium wilt incidence							
1st year (2015-16)	IIOR, Hyderabad	5.3	30.5	3.0	23.9	9.4	100
2nd year (2016-17)		34.7	54.6	19.0	43.7	6.9	100
3rd year (2017-18)		10.7	35.6	23.5	19.0	2.5	92.7
	Mean	16.9	40.2	15.2	28.9	6.3	97.5
1st year (2015-16)	SK Nagar	1.9	52.8	5.5	5.4	0.0	100*
2nd year (2016-17)		27.3	91.8	15.6	0.0	0.0	100
3rd year (2017-18)		17.9	85.2	7.1	19.3	0.0	100
	Mean	15.7	76.6	9.4	8.2	0.0	100
1st year (2015-16)	Palem	30.3	38.5	16.9	31.1	6.0	87.5
2nd year (2016-17)		33.9	49.2	31.3	29.6	4.1	100
3rd year (2017-18)		31.4	68.5	44.1	40.0	3.7	100
	Mean	31.9	52.1	30.8	33.6	4.6	95.8
Gray rot disease severity (%)							
1st year (2015-16)	IIOR, Hyderabad					Susceptible check (DCH-519)	
2nd year (2016-17)	Natural	39.0	53.3	81.3	96.7	99	
3rd year (2017-18)	Artificial*	50.0	50.0	65.0	60.0	85	
	Natural	35.0	25.0	55.0	30.0	95	
	Glasshouse	70.0	30.0	80.0	40.0		

*Using artificial inoculation followed by field fogging technique

Table 7 Reaction of ICH-66 against root rot disease in sick plot at Junagadh (2015-16 to 2017-18)

Year of testing	Root rot incidence (%)				Resistant check	Susceptible check
	ICH-66	DCH-177	DCH-519	GCH-7	JI-357	GCH-4
1st year (2015-16)	17.9	15.0	34.6	15.7	24.5	83.1
2nd year (2016-17)	11.4	36.7	19.2	21.9	9.9	85.8
3rd year (2017-18)	20.0	23.3	0.0	0.0	7.4	68.2
Mean	16.4	25.0	17.9	12.5	13.9	79.0

Table 8 Reaction of ICH-66 against sucking pests (2015-16 to 2017-18)

Pest	Year of testing	Centre	ICH-66	Susceptible check	Susceptible check	Hybrids		
				DPC-9	DCS-107	DCH-519	DCH-177	GCH-7
Leafhopper*	2015-16	Palem	32.6 (1)	-	103.6 (2)	53.4 (0)	35.2 (2)	50.0 (2)
Hopper burn scale (0 to 4)		SK Nagar	2.8	-	3.8	3.3	4.1	4.4
	2016-17	Palem	44.0 (1)	55.8 (4)	-	46.0 (2)	45.2 (1)	44.8 (1)
		Yethapur	14.6 (1)	16.3 (2)	-	6.0 (0)	18.3 (2)	20.6 (1)
		SK Nagar	3.1	20.7	-	2.7	14.4	3.0
	2017-18	Yethapur	6.3 (0)	24.6 (3)	-	3.0 (0)	6.3 (0)	7.0 (0)
		SK Nagar	24.1 (1)	74.9 (4)	-	20.2 (1)	39.1 (3)	22.0 (1)
Thrips/spike	2015-16	Yethapur	3.7	15.2	3.5	9.7	8.0	7.7
	2016-17	Yethapur	32.0	32.0	-	-	-	-
		SK Nagar	12.0	12.1	-	-	-	-
	2017-18	Yethapur	7.3	4.0	-	13.6	9.3	3.6
		SK Nagar	21.9	21.8	-	24.4	19.3	23.0
Thrips/top leaf#	2015-16	SK Nagar	2.4	-	2.4	-	-	-
	2016-17	SK Nagar	1.5	1.3	-	-	-	-
	2017-18	Yethapur	0.6	0.8	-	0.7	0.7	0.8

*Figures in parenthesis indicate hopper burn scale [*Hopper burn grade: 0 - No injury (Highly resistant), 1- Hopper burn up to 10% (Resistant), 2 -11 to 25% (Moderately Resistant), 3-26 to 50% (Susceptible), 4 - above 50% (Highly Susceptible)]; # Figures in parenthesis indicate number of thrips/top leaf

In conclusion, ICH-66 is not only a high-yielding hybrid with better oil content but also possess resistance to wilt, root rot and leafhopper. Due to its better adaptability, it has the potential to replace GCH-4, DCH-177 and DCH-519 in rainfed castor growing regions of peninsular India in *kharif* season especially in states like Telangana, Andhra Pradesh, Karnataka, Tamil Nadu and Odisha.

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