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Identification of Sources of Resistance against Fusarium Wilt of Castor

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Castor (*Ricinus communis* L.) is an important industrial non- edible oilseed crop, which plays a vital role in Indian vegetable oil economy. It is particularly suitable for resource poor farmers located in marginal areas due to its ability to thrive under low rainfall and soil fertility conditions.

Castor oil uses :

Lubricants, paints, soap making, nylon ropes, cosmetics, plastics, textiles, leather industry, transport and pharmaceuticals

Area - 10.96 lakh ha.
Production - 11.43 lakh tons
Productivity - 1261 kg / ha

(source: INDIASTAT, 2013)

Major constraints in castor production

Abiotic constraints

- Prolonged dry spells at vegetative and flowering stages
- Growing of castor in marginal/sub-marginal lands having shallow depth and poor fertility

Biotic constraints

- Botrytis grey rot, Fusarium wilt
- Castor semi-looper, Spodoptera, Capsule borer

Other constraints

- Lack of Quality seed of high yielding varieties/hybrids
- Lack of improved management

Castor diseases

Name of the Disease	Causal organism
Fungal Diseases	
Seedling blight	*Phytophthora parasitica*
Damping-off	*Pythium aphanidermatum*
Root rot	*Macrophomina phaseolina*
Rust	*Melampsora ricini*
Anthracnose	*Colletotrichum ricini*
Collar rot	*Rhizoctonia solani*
Capsule rot	*Cladosporium oxysporum*
Alternaria leaf spot /blight	*Alternaria ricini*
Cercospora leaf spot	*Cercospora ricinella*
Phyllosticta leaf spot	*Phyllosticta basensis*
Powdery mildew	*Leveillula taurica*
Wilt	*Fusarium oxysporum* f.sp. *ricini*

Verticillium wilt	***Verticillium alboatrum***
Botrytis grey rot	***Botrytis ricini***
Fruit rot	***Phytophthora colacasiae***
Nematodes	***Aphelenchoides Meloidogyne sp., Pratylenchus sp., Radopholus similis, Rotylenchulus reniformis***
Bacterial Diseases	
Bacterial leaf spot	***Xanthomonas axonopodis*** **pv.** ***ricinicola***
Bacterial wilt	***Pseudomonas solanacearum***
Crown gall	***Agrobacterium tumefaciens***
Viral Diseases	
Tobacco ring spot	**Tobacco ring spot virus**

Castor crop is threatened by two devastating diseases

Wilt

Grey rot

- **Castor wilt caused by *Fusarium oxysporum* f.sp. *ricini* is one of the yield limiting factors in the major castor growing areas of the state.**
- **The major strategy to manage the disease is to deploy wilt resistant varieties/hybrids.**

- **Host plant resistance as a tactics of disease management can be highly effective looking into the soil-borne nature of the pathogen.**

- **Most of the commercial hybrids are susceptible to wilt, and Long term rotations are not feasible.**

- **Evolution of new races of pathogen that overcome widely used R genes is a continuous process necessitating identification of diverse sources of resistance.**

WILT

Causal organism: *Fusarium oxysporum* f. sp. *ricini*

Symptoms

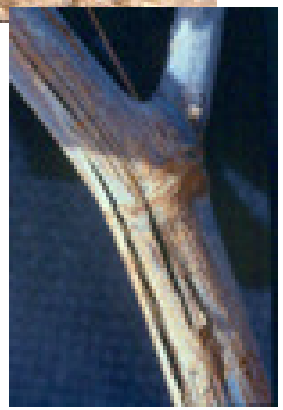
* Seedlings at 2-3 leaf stage exhibit discoloration of hypocotyls, loss of turgidity with or without change in leaf colour

* Usually wilting is preceded by production of leaf blight symptoms and formation of dark stripe on the entire stem up to the infected leaves

* At the time of flowering, gradual yellowing, withering, drying up of leaves and petioles at the apical region followed by drying of entire plant or some of the side branches from tip downwards

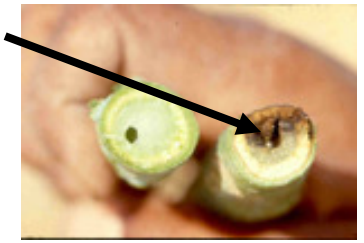
* Transverse and longitudinal sections of the affected roots reveal the presence of the fungus in the vascular tissue and in the xylem parenchyma

* Infected plants rarely bare seeds



Macroconidia on stem

Longitudinal section of stem



Transverse section

Fusarial wilt affected fields

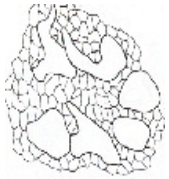
Wilt at vegetative stage

Wilt at maturity stage

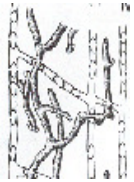
Disease cycle of castor wilt caused by *Fusarium oxysporum* f.sp. *ricini*

Formation of tyloses

Deformation of vessels

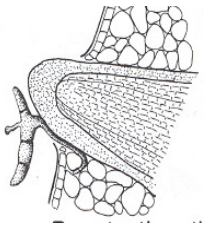


Fungus in xylem vessels



Entry through primary & secondary roots

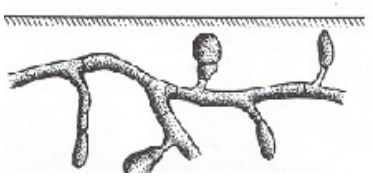
Root infection



Germinating conidia

Microconidia Macroconidia

Production of conidia



Survival in crop debris

Infected castor plant

Stem infection

Blackening of stem

Discoloration of xylem tissue

Fungal growth in pith region

Castor Varieties / Hybrids

S.No	Variety/ Hybrid	Duration (days)	Yield (q/acre)	Special features
1	Kranthi (V)	90 - 150	8 –10	Bold seed Tolerant to drought
2	Haritha (V)	90-180	9 –11	Resistant to Fusarium wilt
3	Kiran (V)	90 -150	7– 8	Low incidence of Grey rot
4	Jwala (V)	90-150	9-10	Resistant to Fusarium wilt
5	DCH-177 (H)	90-180	9-10	Resistant to Fusarium wilt
6	GCH-4 (H)	90-180	9-10	High yielding
7	DCH 519 (H)	90-180	9-10	Resistant to Fusarium wilt
8	PCH-111 (H)	90-180	10-12	Resistant to Fusarium wilt

KRANTI

- 90-150 days
- 13-17 q/ha
- Bold seeds
- Drought tolerant

HARITHA

- 90-180 days
- 14-16 q/ha
- Wilt resistant

KIRAN

- 90-180 days
- 12-15 q/ha
- Drought tolerant

PCH-111

- Wilt Resistant
- Green stem, single bloom, spiny capsule

PCH 222

- Wilt Resistant
- Red Stem, Single bloom, Partially spiny

Hybrids in Pipeline

PCH 234

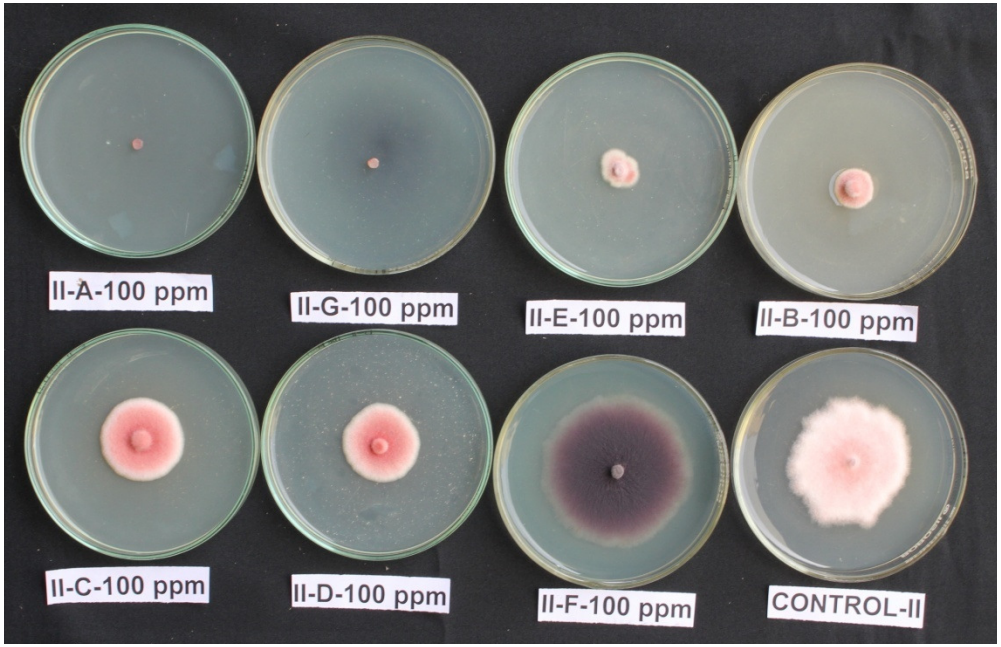
- Wilt Resistant
- Green Stem, Spiny, Single bloom

PCH 244

- Wilt Resistant
- Red Stem , Triple bloom, Spiny

In vitro screening of *Fusarium* isolates with different fungicides

Three isolates of *Fusarium* were screened *in vitro* with twenty fungicides at 100, 250, 500, 1000, 1500 and 2500 ppm.



Five fungicides *viz.,* carbendazim, carbendazim + mancozeb, benomyl, propiconazole and hexaconazole are found effective at 100 ppm.

METHODOLOGY

During *Kharif* 2013, ninteen germplasm lines and 39 advanced breeding material were screened with high disease pressure in wilt sick plot at Regional Agricultural Research Station, Palem, along with susceptible check Kranthi and resistant check Haritha.





Range of Characters in Germplasm

- Stem colour – Green, Red and pink
- Bloom Nature - Zero, Single, Double and Triple
- Capsule Nature – Spiny and non-spiny
- Plant Height (cm) – 34.0 to 151.3 cm
- No. of nodes to primary spike – 7.33 to 19.0
- Primary spike length (cm) – 8.67 to 51.33 cm
- No. of spikes per plant – 1.67 to 11.33
- Single plant yield – 94.00 to 288.0 g

Screening of castor germplasm against wilt disease

Ninteen germplasm accessions supplied by DOR, Hyd. were evaluated for their reaction to wilt disease

Date of sowing – 04-7-2013, Row length – 6m (Sick plot)

Inoculum load of wilt sick plot was maintained by adding *Fusarium* culture mass multiplied on sorghum seeds at regular intervals and maintained through out the season.

Checks – Kranti (Susceptible)

Haritha (Resistant) after every five test entries

Wilt incidence recorded at monthly intervals up to 150 DAS

Inoculum load of wilt sick plot

Month	Inoculum load (c.f.u.)
July - August	$2.0X10^3$
November -December	$2.25X10^3$

- Eight entries were found to be resistant to wilt (< 20 % wilt) up to 150 days after sowing *viz*., RG-1221,1624, 2746, 2781, 2787, 2800, 3105 and RG-3093

- Disease incidence Susceptible Check
- (Kranti) : 90.6%

  Disease incidence Resistant Check (Haritha) : 0.0%

Sl.No.	Germpalsm Entry	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS
1	RG- 1221	0.0	12.5	12.5	18.8	18.8
2	1624	0.0	0.0	0.0	0.0	0.0
3	1631	6.3	6.3	18.8	25.0	31.3
4	1834	18.8	25.0	25.0	37.5	37.5
5	2090	31.3	43.8	56.3	75.0	87.5
6	2430	6.7	13.3	13.3	20.0	26.7
7	2432	15.4	61.5	76.9	84.6	92.3
8	2661	14.3	14.3	28.6	42.9	42.9
9	2746	6.3	6.3	12.5	12.5	12.5
10	2781	0.0	0.0	6.3	6.3	6.3
11	2787	14.3	14.3	14.3	14.3	14.3
12	2800	6.3	6.3	6.3	6.3	12.5
13	2809	9.1	27.3	36.4	45.5	45.5
14	2970	25.0	43.8	62.5	68.8	68.8
15	3016	7.14	35.7	50.0	57.1	57.1
16	3020	8.3	16.7	16.6	25.0	25.0
17	3105	0.0	0.0	0.0	0.0	0.0
18	3089	13.3	33.3	46.6	53.3	53.3
19	3093	6.3	6.3	12.5	12.5	12.5

Testing of advanced breeding material (varieties/hybrids) for their reaction to WILT

IHT (13), IVHT (15) and AVHT (11) entries supplied by DOR, Hyd. were evaluated for their reaction to wilt disease

Date of sowing – 04-7-2013
Design - RBD
Replications - 3
Checks – Kranti (Susceptible)
Haritha (resistant) after every five test entries

Wilt incidence was recorded up to 150 DAS (monthly intervals))

Wilt:

Trial	Entry	Reaction to Wilt
IHT	Nil	Less than 20% wilt infection up to 150 DAS
IVHT	1305, 1308	
AVHT-I	1354	

Wilt incidence in IHT at 30,60,90,120,150 days after sowing

Sl. No.	Entry	30 DAS	60DAS	90DAS	120DAS	150DAS
1	1321	0.00	31.25	37.50	45.83	50.00
2	1322	12.34	27.40	31.57	36.22	41.35
3	1323	20.63	18.25	22.42	30.36	41.07
4	1324	0.00	9.89	20.90	23.93	26.31
5	1325	15.73	26.44	31.60	37.41	37.41
6	1326	15.14	40.56	51.11	63.89	76.67
7	1327	7.87	19.44	23.15	31.02	38.52
8	1328	4.46	21.13	23.51	25.89	27.98
9	1329	2.56	17.22	25.68	33.96	48.32
10	1330	21.58	33.40	49.86	61.47	76.57
11	1331	11.75	16.35	20.79	25.40	34.92
12	1332	14.60	24.13	26.51	33.65	48.10
13	1333	17.22	32.36	47.64	62.92	71.67

Wilt incidence in IVHT at 30,60,90,120,150 days after sowing

Sl. No.	Entry	30 DAS	60DAS	90DAS	120DAS	150DAS
1	1301	4.76	20.24	25.00	31.85	34.23
2	1302	0.00	12.12	20.06	25.87	28.64
3	1303	9.29	34.07	42.88	52.47	57.88
4	1304	4.76	20.32	26.98	29.21	36.19
5	1305	2.08	6.25	17.93	20.0	20.0
6	1306	9.05	29.52	40.00	59.05	59.05
7	1307	7.91	17.48	20.04	24.83	27.61
8	1308	3.03	7.47	9.70	11.92	14.14
9	1309	10.42	29.58	42.22	50.56	54.86
10	1310	15.15	26.34	28.90	31.93	38.00
11	1311	10.71	16.27	16.27	21.83	28.31
12	1312	12.82	19.49	19.49	21.71	29.40
13	1313	13.68	32.82	40.17	44.96	56.41
14	1314	6.53	23.33	27.78	31.94	34.03
15	1315	8.12	14.39	26.00	28.77	37.82

Wilt incidence in AVHT at 30,60,90,120,150 days after sowing

Sl. No.	Entry	30 DAS	60DAS	90DAS	120DAS	150DAS
1	1351	27.8	48.6	60.3	69.5	71.9
2	1352	4.2	23.5	23.5	27.6	36.1
3	1353	9.2	28.0	34.8	44.0	50.6
4	1354	2.1	7.2	9.3	11.9	13.9
5	1355	6.3	34.2	38.3	48.9	51.1
6	1356	2.2	21.7	29.1	31.3	33.5
7	1357	32.4	44.4	63.1	74.4	76.5
8	1358	2.6	17.6	19.8	24.0	24.0
9	1359	11.6	24.8	24.8	33.1	38.8
10	1360	23.4	30.5	32.7	39.7	44.5
11	1361	2.4	16.7	25.6	30.4	32.7

Confirmation of resistance to wilt

- AVHT (11) and germplasm (19) entries were subjected to root dip inoculation and following entries were found to be resistant after 30 days

- RG-1221, 1624, 1631, 2430, 2661,2746, 2781, 2787,2800,3200,3105,3093

- AVHT- 1354,1356,1358,1361

Variability in wilt pathogen *F. oxysporum* f.sp. *ricini*

- **Twenty five isolates of *F. oxysporum* f.sp. *ricini* supplied from DOR were sub cultured on PDA.**
- **The flasks containing sorghum grains were inoculated with *For* cultures and incubated at 27° C and further used for root dip inoculation of following differential hosts**

	Selected variety/Hybrid
1	Kranthi
2	JI-35
3	VP-1
4	48-1
5	Haritha
6	DCS-9

Disease reaction (% wilt incidence) of *Fusarium oxysporum* f.sp. *ricini* isolates on 7 cultivars.

Isolate	Kranti	JI-35	VP-1	48-1	Haritha	DCS-9
FOR-1	S	S	S	R	R	S
FOR-2	S	S	S	S	R	S
FOR-3	S	S	S	R	R	S
FOR-4	S	S	S	R	R	R
FOR-5	S	S	S	R	R	R
FOR-6	S	S	S	R	R	R
FOR-7	S	S	R	R	R	R
FOR-8	S	S	S	R	R	R
FOR-9	S	R	S	R	R	R
FOR-10	S	S	S	R	R	R
FOR-11	S	S	S	R	R	R
FOR-12	S	S	S	R	R	R
FOR-13	S	S	S	R	R	R
FOR-14	R	S	R	R	R	R

Disease reaction (% wilt incidence) of *Fusarium oxysporum* f.sp. *ricini* isolates on 7 cultivars.

Isolate	Kranti	JI-35	VP-1	48-1	Haritha	DCS-9
FOR-15	S	S	S	R	R	R
FOR-16	S	S	S	R	R	R
FOR-17	S	S	R	R	R	R
FOR-18	S	S	S	R	R	R
FOR-19	S	R	S	R	R	R
FOR-20	S	S	S	R	R	R
FOR-21	S	S	S	R	R	R
FOR- 22	S	S	S	R	R	R
FOR-23	S	S	S	R	R	S
FOR-24	S	S	S	R	R	R
FOR- 25	S	S	S	R	R	S

Cv.Kranti,JI-35,VP-1 showed susceptible reaction,whereas, 48-1, harita,DCs-9 showed resistant reaction. Isolates1,2,3 were more virulent


SCREEN HOUSE

Root dip inoculation technique

ROOT DIP INOCULATION TECHNIQUE

Monitoring team visit to wilt sick plot

PCH-111: Hybrid seed production at Gangaram

Hybrid Submitted for Release

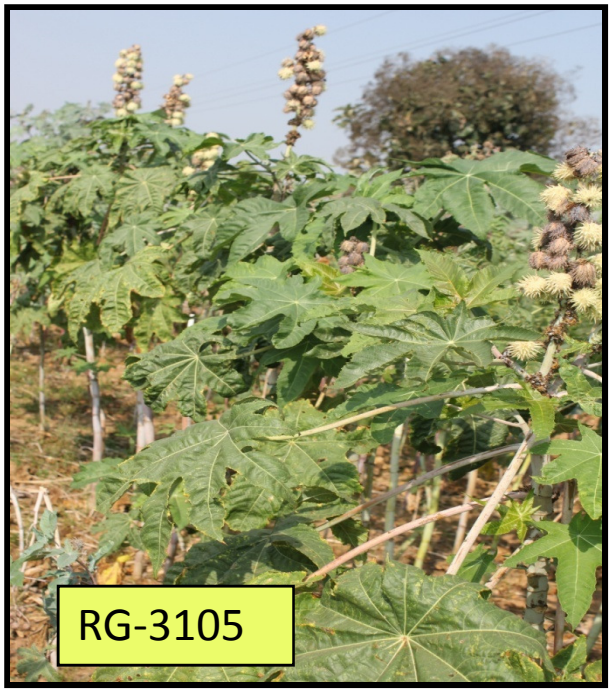
PCH-222, a high yielding wilt resistant castor hybrid, completed 3rd year of minikit testing.

Evalauted in Mahabubnahar, Ranga Reddy, Nalgonda, Kadapa, Kurnool and Warangal districts during *kharif* & *rabi*

Project Director, DOR Dr. K.S. Vara Prasad visited on 30-10-11

Sl.No.	Entry	30 DAS	60 DAS	90 DAS	120 DAS	150 DAS
1	RG-558	0.0	0.0	0.0	0.0	0.0
2	RG-3408	0.0	8.3	16.7	16.7	16.7
3	RG-3017	0.0	14.3	28.6	42.9	42.9
4	RG-3018	0.0	0.0	8.3	8.3	8.3
5	RG-3020	0.0	8.3	16.7	16.7	16.7
6	RG-3041	0.0	13.3	13.3	20.0	26.7
7	RG-3105	0.0	0.0	7.7	7.7	7.7
8	RG-1268	7.7	35.7	57.1	64.3	71.4
9	RG-1631	0.0	8.3	25.0	33.3	41.7
10	RG-1922	0.0	28.6	28.6	28.6	28.6
11	RG-2301	10.0	36.4	54.5	54.5	54.5
12	RG-2388	11.1	20.0	40.0	40.0	40.0
13	RG-2602	7.1	26.7	46.7	46.7	46.7
14	RG-2606	0.0	7.1	14.3	35.7	50.0
15	RG-2661	0.0	0.0	0.0	7.7	15.4
16	RG-2717	0.0	8.3	25.0	33.3	41.7
17	RG-2746	0.0	7.7	15.4	30.8	30.8
18	RG-2758	0.0	13.3	26.7	26.7	33.3
19	RG-2781	0.0	7.1	7.1	7.1	7.1
20	RG-2788	0.0	22.2	33.3	33.3	33.3
21	RG-2820	0.0	13.3	20.0	20.0	26.7
22	RG-2829	0.0	14.3	28.6	35.7	35.7

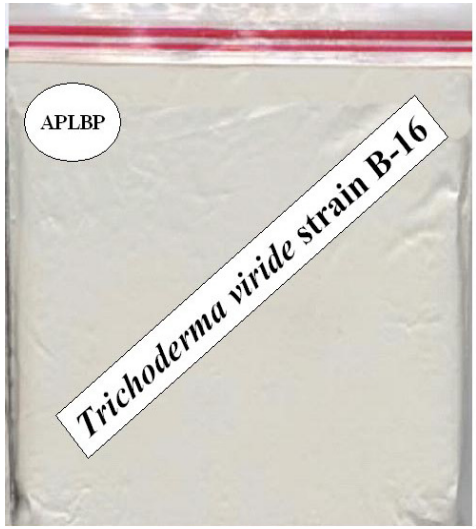
WILT RESISTANT GERMPLASM ACCESSIONS



Management

* Cultivation of crop in low lying and ill drained conditions should be avoided
* Regular removal of diseased plant/plant parts from field reduces inoculum build up and spread
* Crop rotation for 2-3 years with non-host plants like pearl millet, ragi or other cereals play an important role in minimizing the disease intensity
* Seed treatment with thiram @ 3g/kg or bavistin @ 2g/kg of seed
* Grow resistant varieties viz., Haritha, DCS-9, DCH-32, DCH-177, 48-1, GCH-4 etc.

- Seed (10 g/kg) and soil application (1kg/100 kg FYM) of *Trichoderma viride* will reduce the wilt incidence
- Apply more quantity of FYM to the wilt affected plots
- Nematodes – predisposes the plants to wilt – manage nematodes



Talc based Formulation

Seed Treatment

Mixed in Vermicompost

Mixed in Farmyard Manure (FYM)

Conclusion

- **The accessions exhibiting less than 20 percent wilt can be used in breeding programme to incorporate resistance against Fusarium wilt of Castor.**

- **Development of resistant castor varieties against nematode-wilt complex will be a viable approach.**

- **The diverse resistant accessions would serve as base material to develop wilt resistant gene pool with broad genetic base for desirable quantitative traits**

- **and also as promising sources for molecular tagging and mapping of wilt resistantance genes to utilize in marker assisted breeding.**

FUTURE STRATEGIES

- **Development of extra early maturing castor varieties / hybrids with durable resistance to wilt and *Botrytis***
- **Development of new biocontrol agents – molecular methods, mutations**
- **Root enrichment strategy, mixers of bio-agents**
- **Induction of cross protection**
- **Exploitation of systemic acquired resistance**

- **Exploitation of bacteriocins, Endophytes**
- **Screening of new fungicide molecules**
- **Development of molecular kits for early disease diagnosis**
- **Development of location specific IDM strategies**
- **Host differentials for identification of races of *Fusarium* sp.**

Acknowledgements

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THANK YOU