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Inheritance of Fusarium Wilt Resistance and Certain Morphological Characters in Castor (*Ricinus communis* L.)

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ABSTRACT
An experiment was consist of ten parents and six hybrids involving both parents as resistant, one parent resistant and both parents susceptible were screened for wilt reaction under wilt sick plot condition at Main Oilseeds Research Station, Junagadh. Observations were recorded as per cent disease infection in each genotype periodically at thirty days interval upto 150 days after sowing. Out of sixteen castor genotype screened, nine accessions were found to be fusarium wilt resistant with less than 20 per cent wilt incidence. The range of disease incidence was from 0.00 to 100 %. The hybrids, SKP-84 x SKI-215 and JI-368 x SKI-215 involving both resistant parents were showing resistant reaction against wilt, while other four hybrids involving at least one susceptible parent were wilt susceptible under wilt sick plot. Monogenic nature of inheritance was observed for stem colour (mahogany dominant over green and red), internode nature (elongated dominant over condensed), leaf shape (flat dominant over cup), bloom nature (triple dominant over double and single), spiny nature of the capsule (spininess is partially dominant over non-spininess), types of flowers on the primary raceme (monoecious dominant over interspersed and pistillate), shape of the raceme (conical dominant over cylindrical) and compactness of spike suggested that there was the hierarchy of genes for expression could not be judged. Genotypes should be screened for further confirmation of wilt resistance and inheritance of morphological characters. In order to get supporting results for inheritance of morphological traits, related methods should be carried out.
Keywords *- Castor, Inheritance, Fusarium wilt, Morphological characters*

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INTRODUCTION

Oilseeds occupy a pride place in Indian economy next to food grains. Castor (*Ricinus communis* L.) plays an important role in the country's vegetable oil economy. The crop is grown for its non-edible oil (45-50% oil in seeds) which is completely biodegradable with its utilization in several fields such as manufacturing lubricants, printing inks, nylon fibers, hydraulic fluids, cosmetics, varnishes, pharmaceuticals and similar others. The wilt caused by *Fusarium oxysporum* f. *ricini* is the most serious disease of castor recorded in India from Udaipur (Rajasthan) in 1974 [9]. Although plants are infected at early stages of the crop, symptoms are
observed mostly at flowering and spike formation stages. As the wilt of castor is primarily soil-borne, it becomes difficult to manage the disease through chemical or physical means. The only option could be breeding of resistant varieties for which knowledge of genetics of resistance to wilt pathogen is basic necessity. The effectiveness of host-plant resistance in breeding programme largely depends on identification of resistant sources, selection of breeding procedures to incorporate resistance into agronomically superior backgrounds and finally selection of resistant and desirable material to develop high yielding resistant hybrids/varieties. The present study was undertaken to generate information on inheritance of some morphological characters. In castor variation exists for all the characters such as stem pigmentation, waxy coating, leaf shape, spininess of the capsule, internode nature etc. These morphological characters have some economic advantages. For instance mahogany stemmed plants are resistant to castor shoot and capsule borer [16] and triple bloom nature plants are more resistant to jassids [10] and tolerant to drought and cold. Further these traits can also serve as efficient diagnostic characteristic features of varieties, hybrids and their parents.

MATERIAL AND METHODS

For fusarium wilt screening all the ten parents and six selected crosses, each involving two parents with different wilt reactions, *viz.,* resistant x resistant, resistant x susceptible and susceptible x susceptible were selected. The F_1 hybrid of the above crosses along with parents was raised in wilt sick plots during *Kharif* 2017-18 at Main Oilseeds Research Station, Junagadh. The sick plot was developed by repeated incorporation of diseased plant debris and cultivation of wilt susceptible cultivar JI-35. Besides, the soil inoculum load in sick plot was maintained at CFU 2.1 x 103 by mass multiplication of the pathogen isolate on sorghum grains, band application by the side of plants 25 days after planting and incorporation in the top 5-10 cm soil. Wilt incidence was recorded at 30 days of crop growth and thereafter at monthly intervals. The susceptible check JI-35 recorded 80-100% infection. Observations were recorded for per cent wilt incidence at an interval of 30 days from the first appearance of wilt upto crop maturity (150 days). The resistance of the test material was reported only when it was free from any wilt symptoms upto 150 days after sowing, while the susceptible variety showed wilting and died subsequently. Per cent disease infection (PDI) was calculated at 150 days after sowing using the formula [1, 2]:

Wilt incidence (%)

The reaction of the entries under wilt sick plot was assessed by recording the total number of infected plants at regular monthly intervals upto 150 days after sowing. The per cent disease incidence (PDI) was calculated by the following formula,

$$PDI = \frac{\text{Number of infected plants}}{\text{Total number of plants in each genotype}} \times 100$$

Considerable variability was observed among the genotypes for severity of the disease. On the basis of reaction to the disease (PDI), the genotypes were grouped into following categories based on the scale devised by Mew and Ho [8] as follow.

Per cent wilted plants (Scale)	Disease reaction
0-4	Highly resistant (HR)
5-10	Resistant (R)
11-20	Moderately resistant (MR)
21-40	Moderately susceptible (MS)
41-70	Susceptible (S)
71-100	Highly susceptible (HS)

Morphological marker analysis was categorized according to DUS test [3] in Table 2. Observations were recorded in wilt free plot on individual plant basis in parents and 45 F_1 for stem colour (green, mahogany, red), Blooming pattern (single, double, triple), Types of the internodes (condensed, elongated), Shape of the leaf (flat, shallow cup and deep cup), Types of flowers on the primary raceme (pistillate, monoecious and interspersed), Spininess of the capsule (Non spiny, Semi spiny and Spiny), Shape of the spike (Cylindrical and Conical), Compactness of the spike (Compact, Semi compact, Loose). In castor, variation exists for all the qualitative characters.

RESULTS AND DISCUSSIONS

Initial high plant stand in all testing genotypes was maintained in wilt sick plot. None of the genotypes was exhibiting only early wilting or late wilting. Wilt infestation did not stop at a particular stage in any genotypes, it was observed right from germination stage to 150 or 180 days after planting in wilt sick plots. In seedling (2-3 leaves) stage, discoloration of hypocotyls and loss of turgidity of top leaves were observed in wilt infected seedlings. The grown up susceptible plants exhibited typical wilt symptoms like stunted growth, gradual yellowing, shriveling with marginal necrosis and complete drying of leaves and branches, vascular discoloration and death of entire plant. Wilted plants showed blackish lesions above the collar region of stem which further covered the entire stem.

The sixteen castor genotypes were grown in wilt sick plot. The per cent disease incidence was recorded on fusarium wilt symptoms of castor plants from 90 days after sowing and all the entries showed variable reaction to wilt disease incidence. The germination per cent (Table 1) was recorded at 30 days after sowing and it was ranged from 66.66 (VP-1 x JI-35 and SKP-84 x SKI-215) to 93.33 % (JI-368 and JI-368 x

SKI-215). Fusarium wilt symptoms of castor genotypes were recorded at 90, 120 and 150 days after sowing.

The range of disease incidence was from 0.00 to 100 %. Among the genotypes JI-436, JI -368, SKI-215, RG-43 and SKP-84 x SKI-215 showed lowest disease incidence (0.00 %), while VP-1, SKI-346, JI-35, VP-1 x SKI-346 and PCS-124 x VP-1 showed maximum disease incidence (100 %) at 150 DAS. Thus, on the basis of data of per cent disease incidence the genotypes grouped ranged from highly resistant to highly susceptible categories.

Among the genotypes*,* VP-1, SKI-346, JI-35, VP-1 x SKI-346 and PCS-124 x VP-1 showed higher disease incidence. This indicated that these genotypes were highly susceptible. The genotypes *viz.,* SKP-84, JI-436, JI-368, PCS-124, SKI-215, RG-43, SKP-84 x SKI-215 and JI-368 x SKI-215, showed lower disease incidence, indicating that these genotypes were highly resistant. JI-433 was moderate resistant and SKP-84 x JI-35 was found to be susceptible. The results showed that 'sick plot method' was the most ideal for accurate identification of resistance or susceptibility in plants with relative ease. The present results are, in agreement with Anjani *et al*. [4], Lavanya *et al*. [7], Patel and Pathak [11], Shaik [13] and Shaw *et al*. [15] in castor.

Morphological descriptors provide unique identification of cultivated varieties. Among the ten parents only two parents SKP-84 and VP-1 had pistillate nature of flowering. Among the crosses only one cross SKP-84 x VP-1 was pistillate in nature, whereas six parents are interspersed flowering pattern. Monoecious flowering pattern was dominant over pistillate and interspersed flowering pattern. Mahogany coloured stem, elongated internodes, flat leaves were found dominant over green and red colour stem, condensed internodes, deep and shallow cup shaped leaves. In addition to above, shallow cup shaped leaves was dominant over deep cup shaped and only one hybrid (SKP-84 x VP-1) producing deep cup shaped leaves, which involved both parents with deep cup shaped leaves (Table 3).

Neither of parents nor hybrids had no blooming pattern. Triple bloom nature indicating its dominant nature over double and single bloom, partial dominance of spininess over non-spininess with semi spiny as intermediate class; conical shape of spike was dominant over cylindrical spike. The results of all these characters were in agreement with Solanki and Joshi [17], Lavanya and Chandramohan [6], Shankar *et al*. [14], Ramesh [12] and Kinjal [5]. The results for compactness of spike suggested that the hierarchy of genes for the expression of this trait could not be judged. In most of the hybrids semi-compactness of spike was dominant over loose and compact types of spike. In F_1 generations most of the qualitative characters were found dominant but no conformations for the above mentioned results was carried out. In order to get supporting results for inheritance of morphological traits, related methods should be carried out.

Table 1: Germination (%) and per cent of wilt disease incidence of castor genotypes

Sr. No.	Genotypes	Germination percentage	Per cent of wilt disease incidence			Susceptible or Resistance class
			90 DAS	120 DAS	150 DAS	
1	SKP-84	80.00	3.84	3.84	3.84	Highly resistant
2	VP-1	86.66	50.00	100.00	100.00	Highly susceptible
3	JI-436	83.33	0.00	0.00	0.00	Highly resistant
4	JI-433	83.33	16.00	16.00	20.00	Moderate resistant
5	JI-368	93.33	0.00	0.00	0.00	Highly resistant
6	SKI-346	90.00	33.23	94.44	100.00	Highly susceptible
2	PCS-124	86.66	3.84	3.84	3.84	Highly resistant
8	JI-35	80.00	79.16	100.00	100.00	Highly susceptible
9	SKI-215	83.33	0.00	0.00	0.00	Highly resistant
10	RG-43	90.00	0.00	0.00	0.00	Highly resistant
11	SKP-84 x JI-35	83.33	40.00	44.00	48.00	Susceptible
12	VP-1 x JI-35	66.66	65.00	90.00	95.00	Highly susceptible
13	SKP-84 x SKI-215	66.66	0.00	0.00	0.00	Highly resistant
14	VP-1 x SKI-346	86.66	34.61	92.30	100.00	Highly susceptible
15	JI-368 x SKI-215	93.33	3.84	3.84	3.84	Highly resistant
16	PCS-124 x VP-1	76.66	47.82	86.95	100.00	Highly susceptible

Table 2 Description of morphological data of qualitative traits of castor genotypes

S. no.	characters	Legends						
		1	2	3	4	5	7	9
1	Types of flowers	Monoecious	---	---	---	Intersepered	---	Pistillate
2	Blomming pattern	Single	Double	Triple	---	---	---	---
3	Shape of leaf	Flat	Shallow cup	Deep cup	---	---	---	---
4	Types of internodes	Condensed	---	---	---	---	---	Elongated
5	Colour of stem	Green	---	Mahogany	Red	---	---	---
6	Spininess of capsules	Absent	---	---	---	Sparse	---	Dense
7	Shape of spike	---	Cylindrical	Conical	---	---	---	---
8	Compactness of spike	---	---	Loose	---	Semi compact	Compact	---

Table 3 Morphological data of qualitative traits of castor genotypes

Sr. no.	Characters	SKP-84	VP-1	JI-436	JI-433	JI-368	SKI-346	PCS-124	JI-35	SKI-215	RG-43	SKP-84 x VP-1	SKP-84 x JI-436	SKP-84 x JI-433	SKP-84 x JI-368	SKP-84 x SKI-346	SKP-84 x PCS-124	SKP-84 x JI-35	SKP-84 x SKI-215	SKP-84 x RG-43	VP-1 x JI-436	VP-1 x JI-433	VP-1 x JI-368	VP-1 x SKI-346	VP-1 x PCS-124	VP-1 x JI-35	VP-1 x SKI-215	VP-1 x RG-43	JI-436 x JI-433
1	Types of flowers	9	9	5	5	1	5	5	5	5	1	9	5	5	1	5	5	5	5	1	5	5	1	5	5	5	5	1	5
2	Blomming pattern	3	3	3	3	3	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
3	Shape of leaf	3	3	2	2	1	2	2	2	2	1	3	2	2	1	2	2	2	2	1	2	2	1	2	2	2	2	1	2
4	Types of internodes	1	1	9	9	9	1	9	9	9	9	1	9	9	9	1	9	9	9	9	9	9	9	1	9	9	9	9	9
5	Colour of stem	3	1	1	3	3	3	1	1	3	4	3	3	3	3	3	3	3	3	3	1	3	3	3	1	1	3	3	3
6	Spininess of capsule	9	9	9	9	9	1	9	9	1	9	9	9	9	9	5	9	9	5	9	9	9	9	5	9	9	5	9	9
7	Shape of spike	3	3	3	3	2	3	2	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
8	Compact-ness of spike	5	5	5	5	5	7	5	7	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

Sr.no	Characters	Types of flowers	Blomming pattern	Shape of leaf	Types of internodes	Colour of stem	Spininess of capsules	Shape of spike	Compactness of spike
	JI-436 x JI-368	1	3	1	9	3	9	3	5
1	JI-436 x SKI-346	5	3	2	9	3	5	3	5
2	JI-436 x PCS-124	5	3	2	9	1	9	3	5
3	JI-436 x JI-35	5	3	2	9	1	9	3	5
4	JI-436 x SKI-215	5	3	2	9	3	5	3	5
5	JI-436 x RG-43	1	3	1	9	3	9	3	5
6	JI-433 x JI-368	1	3	1	9	3	5	3	5
7	JI-433 x SKI-346	5	3	2	9	3	9	3	5
8	JI-433 x PCS-124	5	3	2	9	3	9	3	5
9	JI-433 x JI-35	5	3	2	9	3	9	3	5
10	JI-433 x SKI-215	5	3	2	9	3	5	3	5
11	JI-433 x RG-43	1	3	1	9	3	9	3	5
12	JI-368 x PCS-124	1	3	1	9	3	5	3	5
13	JI-368 x JI-35	1	3	1	9	3	9	3	5
14	JI-368 x SKI-215	1	3	1	9	3	5	3	5
15	JI-368 x RG-43	1	3	1	9	3	9	2	5
16	SKI-346 x PCS-124	5	2	2	9	3	5	3	5
17	SKI-346 x JI-35	5	2	2	9	3	5	3	5
18	SKI-346 x SKI-215	5	2	2	9	3	1	3	5
19	SKI-346 x RG-43	1	3	1	9	3	9	3	5
20	PCS-124 x JI-35	5	2	2	9	1	9	3	5
21	PCS-124 x SKI-215	5	2	2	9	3	5	3	5
22	PCS-124 x RG-43	1	3	1	9	3	9	2	5
23	JI-35 x SKI-215	5	2	2	9	3	5	3	5
24	JI-35 x RG-43	1	3	1	9	3	9	3	5
25	SKI-215 x RG-43	1	3	1	9	3	5	3	5
26	GCH- 9	5	3	2	9	3	5	3	5

CONCLUSION

On the basis of artificial screening, it was concluded that both parents should be wilt resistant for developing wilt resistant hybrids. The wilt resistant parents *viz*., SKP-84, JI-436, JI-368, PCS-124, SKI-215 and RG-43 could be utilized for getting transgressive segregants with wilt resistance. The results indicated that the hybrids, SKP-84 x SKI-215 and JI-368 x SKI-215 involving both resistant parents were showing resistant reaction against wilt, while other four hybrids involving at least one susceptible parent were wilt susceptible under wilt sick plot. Disease incidence was increased with the advancement of growth. The range of disease incidence was 0 to 100 %.

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