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Effects of Cropping Systems on Wilt of Safflower

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ABSTRACT

Data on feasible cropping systems to be used in semi–arid Vertisols to reduce the soil borne disease of fusarium wilts of safflower is presented. Influence of crop successions and fertilizers on disease incidence and on the progression of wilt during the crop season are discussed. It is suggested that a break in continuous crop successions of safflower in the post rainy season with a legume like chickpea or cowpea intercropped with pigeonpea will reduce the disease incidence of wilt in safflower. This can be used as an effective management practice in heavily infected soils where chemical treatment is impractical and a suitable resistant variety is not available.

Introduction

Fusarium oxysporum f.sp. *carthami* is now one of the serious endemic disease in the safflower growing areas of India (Pedogoankar and Mayee, 1991; AICORPO, 1990). The increase in disease incidence resulting from continuous cultivation of safflower in some areas of Marathawada district in Maharashtra has led to a reduction in the cultivation of the crop in this area (Pedgoankar et al. 1990). Other areas in India now appear to be threatened especially when the crop is grown under irrigation.

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The pathogen survives as chlamydospores in the soil or in diseased plant tissues without losing viability (Chakrabarti, 1980). Infected seeds harvested from wilted plants contribute to the increase in the primary source of the inoculum (Klieswicz, 1963). The severity of the disease seems to be directly related to the use of susceptible varieties (Tara, Bhima, and Manjira), high soil populations and also a cropping history of successive safflower crops (AICORPO, 1990). Similar observations have been seen in other fusarial diseases eg. pigeonpea wilt (Natarajan *et al.* 1985).

One of the ways by which the disease could be managed is by using resistant cultivars. Intensive efforts are being made to identify the sources of resistance and use them for breeding (Sastry and Ramachandram, 1992). While a successful breeding program requires more time for completion, other alternatives like chemical treatments are prohibitively expensive. A quicker measure for containing the disease is the adoption of cultural practices such as crop rotations. Several reports are available in literature on effect of crop rotations on the management of wilts in other crops (Bose, 1938; Upadhyay and Rai, 1981; Mueller et al. 1984) but a cropping systems approach is lacking for safflower. We present here data on the effects of some cropping systems used in semi–arid vertisols on the wilt incidence in safflower. It is suggested that a feasible cropping system approach will provide some control of fusarium wilt in safflower in affected soils.

Materials and Methods

Cropping rotations and systems

Disease incidence was estimated in an ongoing experiment of ICRISAT's Resource Management Program in which the long–term effects of different cropping systems on soil fertility in a Vertisol are being studied (Rego, *et al.* 1989). The experiment investigates a number of cropping systems, four of which are prevalent in dryland farming situations in most areas of Andhra Pradesh and Maharashtra. Crops included were cowpea (*Vigna sinensis* L. savi ex. Harsk.) var. EC 6216; chickpea (*Cicer arietinum* L.) var. Annigeri; pigeonpea (*Cajanus cajan* L. Huth.) var. ICP–16 and safflower (Carthamus tinctorius) var. Manjira. These were grown in rotation with rainy season sorghum (*Sorghum bicolor* L. Moeuch. var CSH 6). The cropping systems, in rotations based on a one or two year cycle are listed in Table 1.

The experiment which commenced in 1983, was laid out in a randomized block design, with three replications and each phase of each rotation was examined in every year. Four nitrogen levels used were: 0, 40, 80, 120 kg / ha in each cropping system. The statistical design includes cropping systems as the main plots and nitrogen treatment as sub–plots.

Disease estimation

The number of wilted and dead plants were recorded at regular intervals of fifteen days starting from 30 days after crop emergence till seed set. Percent wilt data was analyzed after arcsin transformation. At each observation, plants killed due to wilt were counted and up-rooted. Stubble of diseased plants was incorporated in the same plot. Partially wilted plants were not considered in the final estimations. Random samples were also taken for isolation of the fungus from affected plants.

Table 1. Cropping systems with rotations in one or two year cycles

1st year		2nd year		
Rainy (Kharif)	Postrainy (Rabi)	Rainy (Kharif)	Postrainy (Rabi)	Abbreviations used
Sorghum +	Saffiwoer	Sorghum +	Safflower	S+SF-S+SF
Sorghum +	Chickpea	Sorghum +	Safflower	S+CP-S+SF
Cowpea /	Pigeonpea	Sorghum +	Saffiwoer	C/PP-S+SF
Sorghum /	Pigeonpea	Sorghum +	Saffiwoer	S/PP-S+SF

+ denotes sequential cropping; / denotes intercropping.

Soil sampling

Soil samples were collected from the 0–15 cm depth during the crop season to estimate fungal population. Each sample was a composite of a core from five locations in each plot. The mixed sample was shade dried for 48 hours, crushed, and sieved through a 250 sieve mesh.

Isolation of fungus from plant and soil

For isolation of fungus from infected plant parts, a standard procedure was used. Sterilized plant bits from infected stem, collar and root regions were plated in petri dishes containing 20 ml modified Czapeck's Dox medium which contained in addition to normal ingredients, 50 mg PCNB, 25 mg malachite green, 75 mg Dicrysticin–S (Streptopenicillin) plus 2 g yeast extract per litre of the medium. The plates were incubated for 8 days at 20 ± 2℃ with 12 hrs of alternate cycle of dark and light period.

For isolation from soil, 20 mg samples of sieved soil was sprinkled aseptically on 20 ml of modified Czapeck' Dox medium poured in sterile petri plates and incubated in the dark for 3 days before soil sample was sprinkled. These plates were incubated for eight days at 20 ± 2℃ with 12 hours of alternate cycles of dark and light periods. Then the colonies were counted. Ten replications for each sample were taken.

Results and Discussion

Wilt incidence for all treatments is shown as percentage of plants that became infected and died during the season. The incidence was highest in one treatment where safflower was grown successively in post rainy season (S+SF–S+SF) and it increased in the subsequent season (Table 2). The lower incidence was found in treatments where chickpea or cowpea / pigeonpea was grown in the previous season. It was probably due to non–availability of hosts in the succeeding postrainy season. *Fusarium oxysporum* survives in a virulent form in the living host tissue (Nelson, 1991). The practice of cultivation safflower after sorghum grown in the rainy season in Vertisols may thus be ideal for perpetuation of the fungus leading to increased incidence over the years.

Table 2. Effect of various cropping systems on wilt incidence of safflower vis-a-vis yield attributes

	Crop rotation									
	S+SF - S+ SF*		C/PP-S+ SF*		S/PP+S+SF*		S+CP-S+SF*		SE	
Attribute	90-91	91-92	90-91	91-92	90-91	91-92	90-91	91-92	90-91	91-92
Percemt dosease	17.5	33.3	2.36	9.26	9.29	14.7	1.60	9.89	3.01	3.46
	(20.2)	(33.2)	(7.89)	(16.2)	(13.3)	(19.5)	(6.61)	(17.0)	(2.51)	(2.14)
Grain yield (kg/ha)	454	385	472	702	469	669	630	700	84.6	133.5
Stalk yield (kg/ha)	1000	769	1050	1168	973	1286	1246	1279	143.3	190.4
Grain wt. (g/1000 seed)	33.8	31.9	41.8	40.0	39.0	39.0	40.1	41.31	1.00	1.02
Oil content w/w (%)	34.19	28.5	35.58	34.19	34.52	34.91	35	35.09 +NS	0.64	0.44 +NS

Date is mean of 3 replicates; figures in parentheses are arcsin values.

* Refer Table 1.

The progressive increase in the incidence of the disease within a season (Figure 1) was also greater in the safflower grown in successive postrainy season rather than alternated with chickpea or cowpea / pigeonpea. The result was similar in both the seasons. The percent of partially wilted plants in treatments where legume was previously cropped in the postrainy season was marginally higher (personal observation). As compared to this, the crop grown as continuous postrainy season one showed high mortality. Wilt at a later age or occurrence of partial symptom is considered to be an expression of the ability to resist the fungus (Sastry and Ramachandram, 1992). The safflower crop after a previous legume was obviously more healthy; this was also shown by higher grain and dry matter yields (Table 2). Wilt affected plants produce chaffy grain (Sastry, 1992; personal data) and the amount of chaffiness is dependent on age at which plant is attacked. This is shown by increased grain weights of safflower seeds harvested from treatments where a legume was grown in the previous season. Oil yields were not significantly affected.

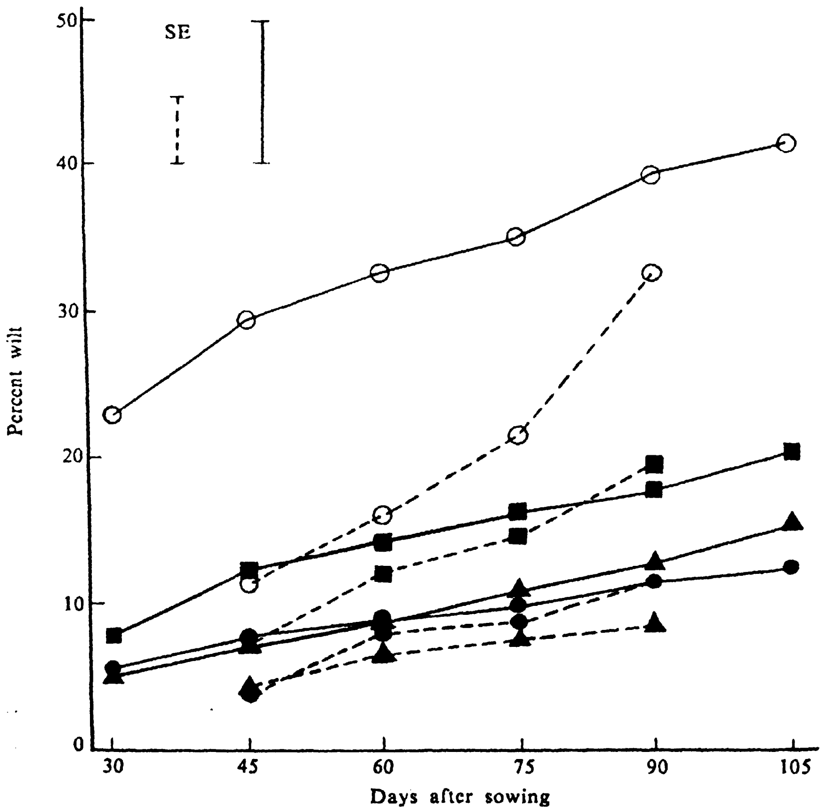

Fig. 1. Progress of wilt disease in safflower grown in different crop rotations

1990 ----- → C / PP–S+SF --●-- S+SF–S+SF --○-- S / PP–S+SF --■-- S+CP–S+SF --▲--

1991 —— → C / PP–S+SF —●— S+SF–S+SF —○— S / PP–S+SF —■— S+CP–S+SF —▲—

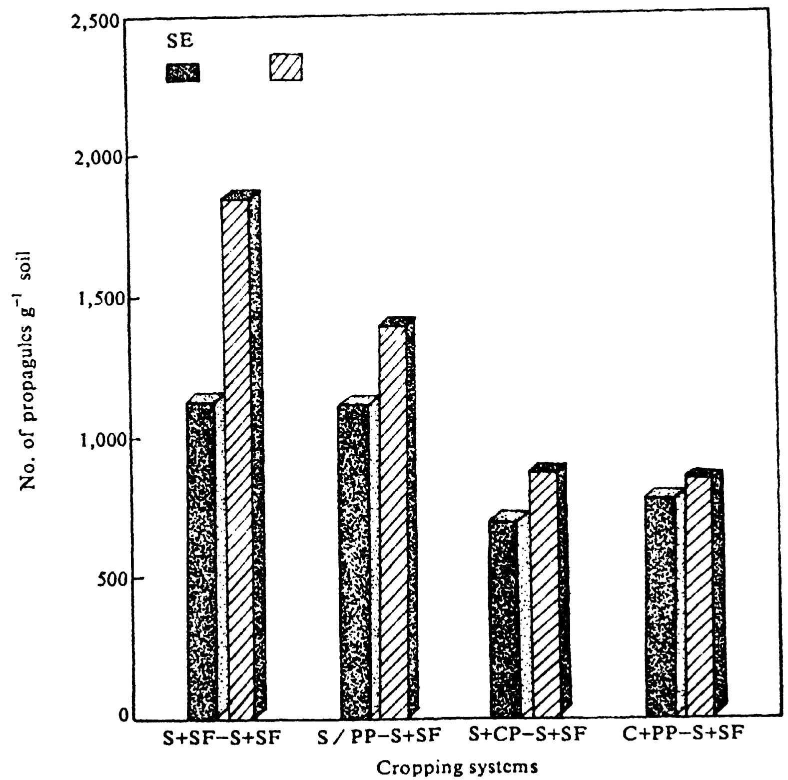

Fig. 2. Populations of *Fusarium oxysporum* in soils under a safflower crop in different crop rotations

1990 1991

Table 3. Effect of cropping systems on fusarial populations in the soil.

Crop rotation	No. of propagules/gm of soil	
	1990-91	1991-92
S+SF-S+SF**	1126[ba]	1845[a]
S/PP-S+SF**	1111[b]	1390[b]
C/PP-S+SF**	771[a]	843[a]
S+CP-S+SF**	696[a]	868[a]
S. E.	48 b	86

* Mean of 3 replicates; each replicate consists of ten plantes.

** Refer Table 1.

Table 4. Effect of nitrogen levels on disease incidence

Croping year	Percent disease				
	N_0	N_{40}	N_{80}	N_{120}	SE
1990-91	5.8	6.0	9.7	9.7	3.16
	(9.3)	(10.1)	(14.6)	(14.4)	
1991-92	17.6	19.7	14.6	16.3	2.63
	(23.3)	(22.3)	(20.1)	(21.1)	

Figures in parentheses indicate arcsin values.

Table 5. Effect of nitrogen levels on fusarial populations in soils

Croping year	No. of propagules per g soil				
	N_0	N_{40}	N_{80}	N_{120}	SE
1990-91	974	935	900	894	40+NS
1991-92	1200	1280	1230	1239	86+NS

The population of fusarial propagules in the soil was also higher in the treatment where safflower was grown in successive seasons (Figure 2) than the two other alternative treatments. It was almost same in treatments where chickpea, or cowpea / pigeonpea were grown. The increase was significant in each of the two seasons examined (Table 3) and propagules increased in all treatments from 1990–91 to 1991–92 season. Soil populations were greater in soils under S / PP–S+SF rotation than under the other two alternating postrainy season safflower treatments, but were significantly less than soils under S+SF–S+SF in each of the two years studied. A respite in postrainy season from safflower cultivation using chickpea, cowpea / pigeonpea appears more effective than pigeonpea in reducing fusarial propagule populations.

Fertilizer nitrogen levels did not influence the disease expression (Table 4) or soil populations (Table 5). Although increased nitrogen levels often caused an increase in the incidence of diseases (Gallegly and Walker, 1949), the influence of soil nitrogen on safflower wilt is not fully understood. It has been suggested that the form of nitrogen in soil (nitrate vs. ammonium) is important for manifestation of wilt disease (Huber and Watson, 1974). Hence, further studies on the form of available nitrogen in the soil profile vis–a–vis wilt disease expression in safflower crop are indicated.

The results presented here suggest that continuous cropping of safflower in successive post rainy seasons despite sorghum grown in intervening rainy season increases the expression of wilt disease leading to higher mortality and lower yields. The build up of inoculum in soils also increases. Wilt incidence as well as fusarial populations in soil are decreased by use of postrainy maturing legumes especially chickpea, cowpea intercropped with pigeonpea. Pigeonpea intercropped with the sorghum seems to have less effect than chickpea. The host specific *Fusaium oxysporum* f. sp. *carthami* does not obviously thrive in these crops. The rhizosphere of chickpea is known to increase the population of antagonistic microflora which check the growth of the pathogen significantly (Chakrabarti, 1979). This can provide a short term remedial measure and is suitable for Maharashtra where the increased cultivation of safflower is being threatened by increasing wilt incidence. A break in the crop sequence by substituting crops with equally profitable returns is needed, in lieu of a lack of suitable resistant variety and practical agrochemical treatments. Thus it may be possible to use legume crops like chickpea, cowpea, pigeonpea as break crops in the postrainy season cropping instead of successive postrainy season safflower crop in the semi–arid Vertisols.

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