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Eco-friendly approaches for the management of Soybean Rust in Karnataka

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Among the four dates of sowing tried at Dharwad (*Kharif* 1996-97 and 1997-98) and Ugar-Khurd (*Kharif* 2001-02 and 2002-03) indicated early sowing i.e., IFN of June at Dharwad and IIFN of May at Ugar-Khurd were found best in reducing rust severity and increasing seed yields in all the genotypes. Among the seven commercially available plant based products tested, neem oil, margotricure, nimbicidine and neem gold at 0.5% and wanis at 1.0% sprayed thrice at an interval of 10 days starting from the onset of disease were found promising. Three sprays of either cow urine @ 10%, cow milk @ 10%, vermiwash @ 50% and panchagavvya @ 3.0% at 10 days interval starting from onset of disease were found best among the different indigenous technology knowledge tested in reducing the rust severity and inceasing the grain yield.

Key words: Eco-friendly, soybean rust, indigenous technology knowledge (ITK), plant based products

INTRODUCTION

Soybean rust caused by *Phakopsora pachyrhizi* Syd. is becoming a major constraint in the cultivation of soybean in parts of Karnataka and Maharashtra. The disease is known to cuase yield loss from 20 to 80 per cent (Anahosur and Patil, 1998). In India the rust has been first noticed at Pantnagar in September, 1970 and subsequently in Kalyani (West Bengal) and in low hills of Uttar Pradesh. It has been very severe in 1970, 1974 and mild in 1972 and 1973 (Singh and Thapliyal, 1977). Presently it is appearing every year in Belgaum, Dharwad and Bagalkot districts of Karnataka and Sangli, Kolhapur and Satara districts of Maharashtra. Many triazole fungicides have been evaluated and recommended for the control of rust (Patil and Anahosur, 1998). However, continuous use of these fungicides may pose the problem of development of resistance and also environmental hazards. On the other hand none of the cultivated genotypes have been found to be resistant to this disease. Under the circumstances stuides have been undertaken at All India Co-ordinated Reserach Project on Soybean, Dharwad centre to identify the possible eco-friendly approaches for the managment of soybean rust in Karnataka.

MATERIALS AND METHODS

Identification of suitable sowing period

In order to identify the suitable sowing period to reduce rust severity, field trials were conducted at Dharwad (*Kharif* 1996-97 and 1997-98) and Ugar--Khurd (*Kharif* 2001-02 and 2002-03). At both the locations four sowing dates were tried using eight genotypes (DSb 1, JS 80-21, MACS 124, PK 1029, MACS 13, Pusa 40, JS 335 and PK 1162) at Dharwad and four (JS 335, DSb 1, PK 1029 and DSb 5) at Ugar-Khurd (Belgaum district). Trial laidout at Dharwad was under rainfed and that at Ugar-Khurd was under irrigated condition. In both the locations trial was laidout in split plot design considering dates as main plot and genotypes as sub plots. The different sowing dates taken at Dharwad and Ugar-Khurd are as follows: Dharwad: D_1 = 14-06-1996 and 14-06-1997; D_2 = 24-06-1996 and 27-06-1997; D_3 = 08-07-1996 and 11-07-1997; D_4 = 24-07-1996 and 29-07-1997; Ugar-Khurd: D_1 = 26-05-2001 and 20-05-2002; D_2 = 08-06-2001 and 05-06-2002; D_3 = 25-06-2001 and 25-06-2002; D_4 = 11-07-2001 and 10-07-2002.

Crop was grown as per package of practices for

higher yields. No control measures were taken for rust and necessary insecticides were sprayed at appropriate time to manage insect pest. Intensity of rust was recorded by following 0 to 9 scale of Mayee and Datar (1986) when the crop was 85-90 days old. For scoring the intensity of disease, ten plants were randomly selected in the central rows of the plot (Wheeler, 1969). Crop was harvested at physiological maturity and the plot yields were taken.

Evalaution of commercial plant based products and indigenous technology knowledge (ITK's) against rust

Field experiments were conducted during *Kharif* 2005 and 2006 at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad in randomized block design with three replications to evaluate plant based products and indigenous technology knowledge (ITK's) against rust using susceptible soybean genotype, JS 335. The different commercially available plant based products used were: soldier (contents : 20% *Agegle marbelus*, 20% *Ricinus communis*, 20% *Hygrophilla spinosa*, 20% *Laminaria*, 20% *Lantana camera*), nimbicidine, margotricure and neem gold (contents: 0.03% EC azadirachtin, 90.5% neem oil, 5.0% hydroxyl EL, 0.5% epichlorohydrate and 3.90% aromax), 20% EC (w/w) wanis (contents: not known), neem oil (crude neem oil) and 5.0% self prepared neem seed kernel extract.

Cow urine and cow milk were collected from dairy unit, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad; vermiwash was collected from vermicomposting unit, Main Agricultural Reserach Station, Dharwad, butter milk was self prepared and kept one month for fermentation at room temperature before its use and panchagavvya was collected from Organic Farming Institute, UAS, Dharwad. To compare these plant based products and ITK's recommended fungicide, hexaconazole 5% EC (RS-2-(2, 4-dichlorophenyl)-1H-1, 2, 4 triazol-1-yl) hexan-2-01) was used as a treated check along with unsprayed control.

Nimbicidine, neemgold, soldier and margotricure, were used at 0.5%, wanis at both 0.5 and 1.0%, neem oil at 1.0% and fungicide hexaconazole at 0.1%, cow urine and butter milk at 10%, vermiwash at 50% and 25%, panchagavvya at 3.0% and butter milk at 2.0% were used.

In case of plant based products and ITK's, three sprays were given at 10 days interval and hexaconazole was sprayed twice at 15 days interval starting with the appearance of rust pustules on the lower leaves of the plants. Intensity of rust was recorded under 0-9 scale of (Mayee and Datar, 1986) when the crop was 85 days old. Further per cent disease index (PDI) was calculated (Wheeler, 1969). Crop was harvested at physiological maturity and the net plot yield was taken.

Table 1a. Effect of date of sowing on severity of rust and seed yield in few genotypes of soybean at Dharwad

Genotypes	*Kharif 1996*									
	Rust severity (0 to 9 scale)					Seed yield (q/ha)				
	D_1	D_2	D_3	D_4	Mean	D_1	D_2	D_3	D_4	Mean
DSb1	1.67	7.33	7.67	6.33	5.75	27.16	12.55	3.70	2.74	11.54
JS 80-21	1.33	4.33	4.67	4.00	3.58	25.00	14.22	9.33	3.90	13.11
MACS124	2.66	6.00	6.33	5.67	5.00	21.88	9.70	3.11	3.12	9.45
PK 1029	1.33	4.33	4.66	3.67	3.50	28.14	16.07	9.75	3.66	14.41
JS 335	2.33	7.67	8.33	7.67	6.50	28.27	10.55	3.87	3.50	11.55
MACS 13	3.00	7.00	7.67	7.33	6.00	25.72	8.79	3.23	2.36	10.02
PUSA 40	1.67	6.00	7.00	5.67	5.08	25.87	9.29	4.92	3.42	10.87
PK 1162	1.33	4.67	4.67	4.00	3.68	27.29	13.11	7.87	3.40	12.92
Mean	1.71	5.91	6.38	5.54		26.17	11.79	5.72	3.26	

CD at 5%		Disease intensity	Seed yield
Between two date means	:	0.44	1.82
Between two genotype means	:	0.81	1.27
Date x genotype	:	1.06	2.61

Table 1b. Effect of date of sowing on severity of rust and seed yield in few genotypes of soybean at Dharwad

Genotypes	*Kharif 1997*									
	Rust severity (0 to 9 scale)					Seed yield (q/ha)				
	D_1	D_2	D_3	D_4	Mean	D_1	D_2	D_3	D_4	Mean
DSb 1	2.00	3.67	4.66	3.67	3.50	26.85	21.01	6.53	2.66	14.26
JS 80-21	1.67	3.00	3.33	2.67	2.67	26.38	22.02	9.02	3.05	15.12
MACS 124	2.67	4.33	5.33	4.00	4.08	26.24	20.70	7.37	1.72	14.01
PK 1029	1.33	2.67	3.00	2.33	2.33	27.09	24.24	12.13	3.55	16.75
MACS 13	2.67	4.67	5.67	4.00	4.25	26.68	20.20	7.44	2.08	14.10
PUSA 40	2.00	4.00	5.00	3.67	3.67	27.16	20.07	7.16	2.83	14.31
JS 335	2.33	4.67	6.00	4.00	4.25	27.51	19.57	7.88	3.19	14.54
PK 1162	1.33	2.67	3.00	2.33	2.25	29.61	23.74	12.68	3.38	17.35
Mean	2.00	3.67	4.50	3.33		27.19	21.44	8.78	2.81	

CD at 5%		Disease intensity	Seed yield
Between two date means	:	0.25	1.89
Between two genotype means	:	0.40	1.83
Date x genotype	:	0.80	3.67

RESULTS AND DISCUSSION

Identification of suitable sowing period at Dharwad

During *kharif* 1996, significantly low intensity of rust and high yields were recorded in the crop sown during first fortnight (IFN) of June compared to rest of the dates tried. Among the different genotypes tested high intensity of rust was recorded in JS 335 (6.50), MACS 13(6.00) and DSb 1 (5.75) and significantly low intensity of rust was observed in PK 1029 (3.50), JS 80-21 (3.58) and PK 1162 (3.68). Among the genotypes the only significant yielder was PK 1029 (14.41 q/ha). In early sowing (IFN of June) JS 335 (28.27 q/ha), PK 1029 (28.14 q/ha). PK 1162(27.29 q/ha), DSb 1 (27.16 q/ha) and Pusa 40 (25.87 q/ha) were performed superior. However the genotypes PK 1029 and JS 80-21 gave higher yields even in late sowings (Table 1a). Almost similar results were obtained during *kharif* 1997 also. Crop sown during IFN June recorded significantly low rust intensity with higher yields compared to rest of the dates tried. Among the genotypes, PK 1162 and PK 1029 gave significantly higher yields over the other genotypes (Table 1b).

Table 2a. Effect of date of sowing on severity of rust and seed yield in few genotypes of soybean at Ugar Khurd

Genotypes	*Kharif 2001*									
	Rust severity (Per cent disease index)					Seed yield (q/ha)				
	D_1	D_2	D_3	D_4	Mean	D_1	D_2	D_3	D_4	Mean
JS 335	5.56**	7.13	9.51	8.25	7.61	27.63	16.66	9.13	4.13	14.38
	(25.92)*	(59.30)	(99.90)	(85.20)	(67.58)					
DSb 3	5.35	6.98	9.51	8.07	7.48	23.65	16.34	8.21	3.21	12.85
	(22.22)	(55.50)	(99.90)	(81.50)	(64.78)					
PK 1029	0.71	5.77	7.13	6.45	5.02	24.22	20.80	18.42	8.42	17.96
	(0.00)	(29.60)	(59.30)	(37.00)	(31.48)					
DSb 5	0.71	5.98	7.28	6.33	5.08	22.06	17.86	12.57	5.57	14.52
	(0.00)	(33.33)	(63.00)	(40.70)	(34.26)					
Mean	3.08	6.47	8.36	7.20	6.28	24.39	17.91	12.08	5.33	14.93
	(12.04)	(44.43)	(80.53)	(60.10)	(49.53)					

*-Original percentage values, ** $\sqrt{x+0.5}$ transformed values

CD at 5%		Disease intensity	Seed yield
Between two date means	:	0.13	1.39
Between two genotype means	:	0.12	0.91
Date x genotype	:	0.23	1.83

At Ugar Khurd :

The different sowing dates tried during *kharif* 2001 at Ugar-Khurd under irrigated condition indicated significantly low intensity of rust on early sown crop i.e., during IIFN of May (12.04%) compared to rest of the dates tried. Highest severity of rust was recorded on crop sown during IIFN of June (80.53%). No incidence of rust was recorded on moderately resistant genotypes (PK 1029 and DSb-5) sown during IIFN of May.

Khurd ealry sowing i.e., IFN of June and IIFN of May,respectively, recorded low rust severity irrespective of the genotypes. Normally at Ugar-Khurd (Belgaum district) and Dharwad rust appears during IFN of August and IIFN of August or IFN of September, respectively. By this time the early maturing genotype like JS 335 may attain the stage of physiological maturity and no much loses in yield due to rust appearnace at this stage. The low disease severity and increased yield in genotypes *viz.,* JS 80-21, PK 1029, PK 1162 and DSb 5 in

Table 2b. Effect of date of sowing on severity of rust and seed yield in few genotypes of soybean at Ugar Khurd

Genotypes	*Kharif 2002*									
	Rust severity (Per cent disease index)					Seed yield (q/ha)				
	D_1	D_2	D_3	D_4	Mean	D_1	D_2	D_3	D_4	Mean
JS 335	5.98 (35.24)	7.28 (52.56)	9.51 (90.00)	7.74 (59.51)	7.63 (59.33)	27.22	18.52	12.22	6.85	16.20
DSb 3	5.77 (32.86)	6.23 (50.36)	9.51 (90.00)	7.59 (57.14)	7.28 (57.59)	24.81	16.67	10.37	6.11	14.49
PK 1029	3.22	5.77	6.82	6.15	5.49	26.11	24.07	15.74	9.07	18.75
DSb 5	4.47	5.98	7.13	6.33	5.98	27.04	24.62	13.33	8.51	18.38
Mean	4.86 (25.13)	6.32 (42.76)	8.24 (69.10)	6.95 (48.42)	6.60 (46.35)	26.29	20.97	12.92	7.64	16.96

*-Original percentage values, ** $\sqrt{x+0.5}$ transformed values

CD at 5%		Disease intensity	Seed yield
Between two date means	:	0.39	0.59
Between two genotype means	:	0.44	0.42
Date x genotype	:	0.85	0.93

At first date of sowing (IIFN of May) JS 335 recorded significantly higher seed yield compared to other genotypes. Whereas at D_2 (IFN of June), D_3 (IIFN of June) and D_4 (IFN of July) PK 1029 recorded significantly higher seed yield. Overall crop sown during IIFN of May recorded significantly higher seed yield compared to other date of sowing (Table 2a).

Almost similar results were obtained during *khariif* 2002, where in early sowing i.e., IIFN of May recorded significantly low intensity of rust with higher seed yields compared to other dates of sowing. PK 1029 recorded higher seed yields in all the dates of sowing except in D_1 (IIFN of May) where JS 335 recorded higher seed yields (Table 2b).

The differences in severity of rust in different dates of sowing is attributed to the weather conditions. In the present investigation both at Dharwad and Ugar-early sowings was because of their rust tolerance and late appearance of rust. Several reports are available in reducing the disease severity with early sowings in different crops (Anahosur *et al.,* 1982, Hundekar, 1999; Patil and Basavaraja, 2002).

Evaluation of commercial plant based products agaisnt rust

Rust severity: Rust severity during both the years and also pooled data indicated significant difference among the treatments. During 2005, lowest rust severity of 59.25 per cent was recorded in check fungicide hexaconazole followed by wanis @ 1.0% (67.89%), neem gold (70.36%), neem oil (72.83%) and wanis @ 0.5% (72.83%). However, they were on par with each other. Margo tricure (77.77%), nimbicidine (87.64%) and soldier (87.65%) were found next best and on par with each other. Maximum rust severity of 95.05 per cent was recorded in unsprayed control. Almost similar results

Table 3: Effect of plant based products on rust severity and seed yield of soybean

Treatments	Per cent disease index			Seed yield (q/ha)			B:C ratio
	2005	2006	Pooled	2005	2006	Pooled	(Mean)
T_1: Nimbicidine @ 0.5%	69.67*	39.57	54.62				
	(87.64)**	(40.74)	(64.19)	27.51	30.91	29.21	0.96
T_2: Neemgold @ 0.5%	57.17	49.70	53.43				
	(70.36)	(58.02)	(64.19)	27.78	29.15	28.46	0.50
T_3: Soldier @ 0.5%	69.67	52.63	61.15				
	(87.65)	(62.95)	(75.30)	24.97	28.55	26.76	–0.69
T_4: Wanis @ 0.5%	58.80	63.73	61.27				
	(72.83)	(80.24)	(76.54)	27.89	26.91	27.40	–0.31
T_5: Wanis @ 1.0%	55.50	57.13	56.32				
	(67.89)	(70.36)	(69.13)	28.37	27.99	28.18	–0.52
T_6: Margotricure @ 0.5%	61.90	46.77	54.33				
	(77.77)	(53.08)	(65.43)	28.06	30.05	29.05	1.12
T_7: Neem seed kernel	77.00	49.63	63.32				
extract @ 5.0%	(92.58)	(58.02)	(75.32)	26.15	31.01	28.58	0.67
T_8: Neem oil @ 1.0%	58.77	43.90	51.33				
	(72.83)	(48.14)	(60.49)	28.88	31.58	30.23	2.74
T_9: Hexaconazole @ 0.1%	50.40	30.47	40.43				
	(59.25)	(25.92)	(42.59)	29.64	32.96	31.30	4.85
T_{10}: Untreated control	79.27	84.73	82.00				
	(95.05)	(97.52)	(96.29)	25.68	24.44	25.06	—
SEm±	3.31	2.95	2.16	1.00	2.49	1.38	
CD at 5%	9.82	8.69	5.97	NS	NS	3.81	
CV (%)	8.97	10.10	9.17	6.32	14.58	11.95	

*Arcsine transformed values **Original percentae values NS = Non significant

Cost of grains @ Rs. 1300/- per quintal; Labour charges for one spray per hectare Rs. 125/-; Quantity of spray solution used per hectare, 1st spray: 625 litrers, 2nd and 3rd spray: 750 liters; cost of plant based pesticides and fungicide in Rs/kg or litre, nimbicidine (200), neem gold (200), soldier (560), wanis (340), mangotricure (175), neem oil (60), neem seed (5), hexaconazole (700).

were obtained during 2006 also. Check fungicide hexaconazole was found best in reducing the rust severity (25.92%). Nimibicidine (40.74%), neem oil (48.14%), margotricure (53.08%), neem seed kernel extract (58.02%) and wanis @1.0% (70.36%) were found next best and on par with each other. Pooled data also indicated superiority of hexaconazole over other plant based products in reducing rust severity. Neem oil (60.49%), margotricure (65.43%), nimbicidine (64.19%), neem gold (64.19%) and wanis (69.13%) were found on par and next best in reducing rust severity. Unsprayed control recorded highest rust severity of 96.29 per cent (Table 3).

Seed yield (q/ha) Seed yield in different treatments during both the years (2005 and 2006) was found non significant. However pooled data indicated significant differences among the treatments. Highest seed yield was recorded in hexaconazole (31.23 q/ha) followed by nimbicidine (29.21 q/ha), margotricure (29.05 q/ha), neem seed kernel extract (28.18 q/ha). However, they were on par with each other. Unsprayed control recorded least yield of 25.06 q/ha and was on par with soldier (26.76 q/ha) and wanis at 0.5% (27.40 q/ha) (Table 3).

B:C ratio: Estimation of benefit cost ratio is an important aspect in the economics of managment of plant disease. In the present study, highest B:C ratio was obtained from hexaconazole (4.85) followed by neem oil (2.74) and margotricure (1.12). Lowest B:C ratio of 0.69 was recorded in soldier followed by wanis @ 1.0% (-0.52) and wanis @ 0.5% (-0.31) (Table 3).

Several earlier workers have reported the effectiveness of plant based products in the control of plant diseases of different crops (Wadhwani *et al.*, 1986; Gandpathy and Narayanaswamy, 1990; Usman *et al.*, 1991; Hundekar, 1999). Fugro (2000) recommended the integrated use of organic manures, inorganic fertilizers, garlic extract and cow urine sprays in controlling foliar diseases of chilli.

Jones *et al.* (1989) reported the chemical nature of neem products used as fungitoxicants. The active

Table 4: Evaluation of indigenous technology knowledge (ITK's) against rust of soybean.

Treatments	Percent disease index (PDI)			Yiled (q/ha)		
	2005	2006	Pooled	2005	2006	Pooled
T_1-Cow urine @ 10%	58.98* (72.83)**	51.07 (60.49)	55.02 (66.66)	26.23	28.89	27.56
T_2-Vermiwash @ 50%	58.77 (58.98)	48.93 (56.79)	53.85 (57.86)	23.98	28.23	26.10
T_3-Vermiwash @ 25%	61.89 (77.77)	64.37 (80.24)	63.13 (79.00)	22.91	26.45	24.68
T_4-Cow milk @ 10%	55.54 (67.89)	45.33 (50.61)	50.42 (59.25)	25.01	28.61	26.81
T_5-Panchagavvya @ 3.0%	79.28 (95.05)	60.27 (75.30)	69.77 (85.18)	25.02	27.38	26.20
T_6-Butter milk @ 2.0%	71.93 (90.11)	71.93 (90.11)	71.93 (90.11)	24.73	26.24	25.48
T_7-Hexaconazole @ 0.1%	51.16 (60.49)	38.13 (38.27)	44.63 (64.19)	29.30	33.09	31.20
SEm±	3.71	3.87	2.68	1.43	1.14	0.91
CD at 5%	10.82	11.31	7.41	4.18	3.32	2.51
CV (%)	9.48	11.40	10.37	10.50	7.08	8.70

*Arcsine transformed values **Original percentage values

principle for antifungal and antibacterial activity of *Curcuma longa* and *Azadirachta indica* was reported to be the protein part of the plant extract. Similarly the antibacterial activity of *Adhatoda vasica* and *Prosopis juliflora* might be explained to have higher levels of glycoprotein and tannin. Present investigation has also identified the antifungal properties in some in some of the commercially available plant products such as neem oil, margo tricure, nimbicidine, neem gold and wanis. These can be certainly used for the effective eco-friendly managment of soybean rust.

Evaluation of indigenous technology knowledge (ITK's) against rust

Rust severity: Rust severity during both the years including their pooled data clearly indicated significant difference among the treatments. Check fungicide, hexaconazole recorded significantly low rust severity (44.63%) followed by cow milk (50.42%) and were on par with each other. Cow urine @ 10% and vermiwash @ 50% were found next best in reducing the rust severity and were on par with each other (Table 4).

Seed yield : Hexaconazole was significantly superior over other treatments and recorded highest seed yield of 31.20 q/ha. Next best treatment was cow urine (27.56 q/ha) followed by cow milk (26.81 q/ha) and vermiwash @ 50% (26.10 q/ha), however all were on par with each other. Lowest seed yield of 24.68 q/ha was recorded with vermiwash @ 25% and was on par with butter milk @ 2.0% (25.48 q/ha) (Table 4). Several workers used animal urine for the managment of plant diseases (Gupta, 1989; Verma and Pathak, 1998; Raja *et al.,* 2006). Kannan *et al.*(2007) reported the mechanism involved in control of plant diseases with animal urines. According to them animal urine spray increases the total and ortho-dihydroxy phenol content and also peroxidase, polyphenol oxidase and phenylalanine ammonia lyase enzymatic activities. Overall phenomenon of induced systemic resistance mechanism operates which is associated with the induction of phenolic content and enzyme activity which inturn gave defence to plants against invading pathogens. Ammonia and nitrous acid present in buffalo urine are responsible to kill sclerotia of *Rhizoctonia solani* (Raja *et al.,* 2006). The present investigation identifies the antifungal properties in the indigenous products like cow urine, cow milk and vermiwash which can be used in the managment of soybean rust.

Overall the present investigation recommends the early sowing (IIFN of May under irrigated condition and IFN of June under assured rainfall rainfed condition) with early maturing (JS 335) and rust tolerant (PK 1029) genotypes and spraying either with commercially available plant based products (neem oil and margotricure) or indigenous products

(cow urine, cow milk and vermiwash) as eco-friendly approaches for the managments of soybean rust in Karnataka.

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