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Identification of Sources of Resistance and Yield Loss Assessment for Aerial Blight and Anthracnose/Pod Blight Diseases in Soybean

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ABSTRACT

Background: Aerial blight (*Rhizoctonia solani* Kuhn) and Anthracnose/pod blight (*Colletotrichum truncatum*) are important soybean diseases, affect most of the present varieties with varying intensity, in India. There are also few reports of resistance against both the diseases.

Methods: To identify resistance, a set of 121 diverse soybean genotypes including six susceptible checks *i.e.* JS 93-05, JS 335, JS 72-280, Punjab 1, RKS 18 and VLS 58 were evaluated under high disease pressure field conditions during 2017, 2018 and 2019. Moreover, assessment of yield losses due to these diseases were also worked out in highly infected plants of susceptible checks.

Result: It was observed that aerial blight (0.0-46.8 per cent) and anthracnose/pod blight (0.0-56.2 per cent) were affected soybean genotypes from R1 to R7 and V3 to R7 stages, respectively. The genotypes responded differently and showed absolute resistance to susceptible reaction. Out of 121 genotypes, only five genotypes *i.e.* JS 20-57, JSM 222, MACS 1407, PS 1611 and Cat 2126 B were found to be highly resistant against both the diseases. Per cent pod and yield losses were significantly correlated with varying severity of aerial blight (0.966** and 0.995**) and anthracnose/pod blight (0.957** and 0.995**), respectively. However, the highest yield loss of 41.0 and 64.8 per cent were recorded on 55.6 and 75.2 per cent disease index (at 90 days) of aerial blight and anthracnose/pod blight, respectively.

Key words: Aerial blight, Anthracnose/pod blight, Resistance, Soybean, Yield losses.

INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is a highly valuable legume which ranks first among the oilseeds in the world. The area and production of soybean in India was 10.83 million ha and 10.93 million ton during 2018-19 (SOPA, 2020). In this, Madhya Pradesh is the key state which grows and produces more than 50 per cent of country's soybean. In India, nearly ninety eight per cent areas under cultivation of soybean is rainfed (Dupare *et al*., 2014) and therefore, it has to face many biotic and abiotic stresses from germination to harvesting. The yield potential of recent varieties of soybean is higher (about 2.1 t/ha) as compared to average productivity (1.2 t/ha) of the country (Agrawal *et al*., 2013). Soybean is known to be affected by more than 100 pathogens (Sinclair and Shurlleff, 1975) across the world and currently about eighteen diseases are infecting the soybean crop in India (Anonymous, 2018).

Among this, aerial or foliar blight caused by *Rhizoctonia solani* Kuhn, which also infect the soybean crop across the world (Jones and Belmar, 1989; Wan *et al*., 2005 and Williamson *et al*., 2006) and causes significant yield loss in top eight soybean producing countries (Wrather *et al*., 2010), is a prominent soybean disease in India. It is more severe particularly in the state of Uttarakhand, Madhya Pradesh and Chhatisgarh (Wrather *et al*., 2010 and Mathpal and Singh, 2017) and favors by high humid field conditions (Yang *et al*., 1990). Another disease, soybean anthracnose caused by *Colletotrichum truncatum* (Schw.) Andrus and Moore, infects above ground parts and pods (Pod blight) of soybean and favors by warm humid weather (Sharma *et al*., 2011) is presently the second most wide spread disease in the country (Anonymous, 2012). Anthracnose is also reported from many soybean growing countries (Manandhar and Hartman, 1999) and causes considerable monetary losses (Wrather and Koenning, 2006).

Varietal resistance is always very effective and best way to manage and reduce the yield losses caused by diseases. At present, there are few reports of resistance/tolerance against aerial blight and anthracnose/pod blight diseases of soybean in India (Sharma *et al*., 2016) and this may be varied under different environmental conditions. In view of this, the present investigation was undertaken to identify the field resistance against both the diseases so that these

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genotypes may be utilized in contemporary resistance breeding programme. Moreover, the yield loss assessment was also worked out to quantify the losses due to higher level of disease severity in different varieties.

MATERIALS AND METHODS

Experimental details

An experiment was carried out to identify source of resistance against aerial blight or Rhizoctonia aerial blight (RAB) and Anthracnose/pod blight diseases of soybean in the field of All India Coordinated Research Project (AICRP) on Soybean at J.N.K.V.V., Jabalpur (Latitude: 23°14 N, Longitude: 79°56 E, Altitude: 411.5m) during *Kharif* 2017, 2018 and 2019. The AICRP on soybean has identified this centre as hot spot for Aerial blight. Whereas anthracnose and pod blight were also occurred every year with varying severity at this place. In this field trial, a set of one hundred twenty one valuable soybean genotypes (released varieties, exotic lines and advanced lines) including six susceptible checks *i.e* JS 93-05, JS 335, JS 72-280, Punjab 1, RKS 18 and VLS 58 were evaluated for resistance. Primarily, seeds were treated with thiomethoxam 30% FS @ 10 ml/kg to protect the insect pest *i.e*. white fly and others at initial stage of crop. Thereafter showing was done in two rows (4 m length and 40 cm spacing) in augmented plot between 28th to 30th June each year. All the genotypes were taken care as per the recommended packages and practices except application of fungicides. The crop was regularly observed for incidence and severity of aerial blight and anthracnose and or pod blight.

Observations for Aerial blight

The severity of aerial blight was recorded from fifteen randomly selected plants at 80-90 days after sowing (before maturity). Selected plants were approximately divided into three positions as bottom, middle and top and from each position two to four leaves were graded. In grading, 0-9 scores were given on the basis of per cent leaf area infected (Mayee and Datar, 1986). The per cent disease index (PDI) was calculated for aerial blight by using the formula given by Wheeler (1969).

$$PDI = \frac{\text{Sum of individual rating}}{\text{Number of examined leaves} \times \text{Maximum disease rating}} \times 100$$

Observations for Anthracnose/pod blight

Anthracnose primarily affects stem and petioles and thereafter pods or in some cases only pods. Therefore, both plants (stems, petioles and leaves) and pods were observed critically and 0-9 ranting were given separately for plant and pods on the basis of area affected by anthracnose lesions. Firstly, 15-20 randomly selected plants and thereafter, 45-60 randomly selected pods from these plants were assigned infection rating. Both these infection grades were then utilized in the calculation of per cent disease index (PDI) for anthracnose/ pod blight by using the formula given by Wheeler (1969).

Infection rating of anthracnose/pod blight

Ratings	Descriptions
0	No lesions on plant or pod
1	Up to 1% plant or pod area covered with lesions
3	>1.0 to 10% plant or pod area covered with lesions
5	>10 to 25% plant or pod area covered with lesions
7	> 25 to 50% plant or pod area covered with lesions
9	> 50 % plant or pod area covered with lesions

On the basis of per cent disease index (PDI), the genotypes were categorized in different class of resistance and susceptibility as given below:

PDI	Categories
0.0	Absolutely resistant (AR)
>0.0 - 1.0	Highly resistant (HR)
>1.0 - 10.0	Moderately resistant (MR)
>10.0 - 25.0	Moderately susceptible (MS)
>25.0 - 50.0	Susceptible (S)
> 50.0	Highly susceptible (HS)

Estimation of yield losses

For yield losses assessment, ten to fifteen highly infected plants (for each, aerial blight and anthracnose/pod blight) of each susceptible check varieties (six) from each replication (three replications/blocks) were selected and per cent disease index (at 90 days) was worked out for both the diseases separately. Numbers of pods and bulked yield from affected/diseased plants were recorded. Simultaneously, pods and yield were also recorded from healthy plants (free from any disease) from similar plot. Thereafter, numbers of pods and yield per affected/diseased plant (Actual outcome) and per healthy plant (Expected outcome) were worked out. By using this, per cent pods and yield losses [((Expected outcome - Actual outcome)/ Expected outcome) x 100] were calculated. Correlation and regression functions were also derived between per cent disease severity and per cent (pod and yield) losses.

RESULTS AND DISCUSSION

Appearance and distribution of diseases

In three years, it had been noticed that symptoms of aerial blight (Fig 1) and anthracnose/pod blight (Fig 2) usually appeared between first to second week of August [bloom initiation (R1) to full bloom (R2) stages] and last week of July to first week of September [vegetative third node (V3) to full pod (R4) stages], respectively. The severity of aerial blight (0.0-21.8, 0.0-42.3 and 0.0-46.8 per cent) and anthracnose/pod blight (0.0-24.6, 0.0-38.7 and 0.0-56.2 per cent) varied in different genotypes during 2017, 2018 and 2019, respectively (Fig 3 and 4). In 2019, the disease severity was higher and most of the genotypes were found to be affected by aerial blight and anthracnose/pod blight with mean severity of 14.08 and 15.11 per cent, respectively.



Fig 1: Close up of aerial blight affected soybean foliages showing water soaked grayish brown lesions with aerial mycelium of pathogen.

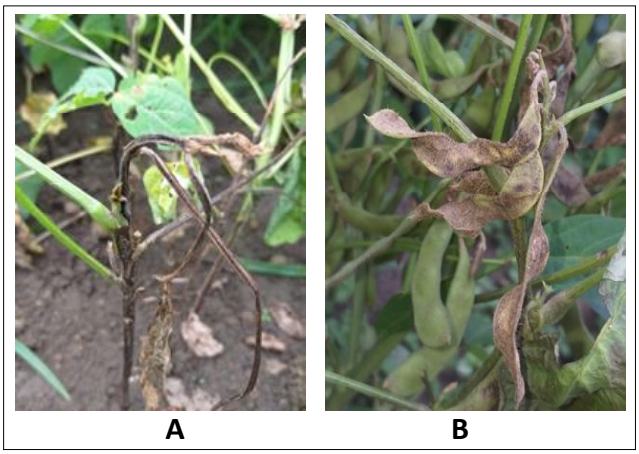


Fig 2: Complete blackening of stem in early stage (A) and pod blight during pod development stages (B) due to anthracnose/ pod blight, respectively.

Resistance to aerial blight

Out of one hundred twenty one, only six namely JS 20-30, JS 20-57, JSM 222, MACS 1407, PS 1611and Cat 2126 B were found to be highly resistant against aerial blight disease of soybean (Table 1). Whereas fifty genotypes reacted as moderately resistant and rest were found to be moderately susceptible (54) to susceptible (11). The check varieties VLS 58 and RKS 18 were reacted susceptible with more than 25 per cent severity. Before this, Patel (2011) and Amrate *et al*. (2018) were also evaluated several genotypes and found highly resistant to highly susceptible reaction against aerial blight in central Indian conditions. Amrate *et al.* (2020) also screened sixty important soybean genotypes for major diseases and found that aerial blight was severe and most of them reacted as moderately susceptible.

Resistance to anthracnose and pod blight

For anthracnose/pod blight, only fifteen, therein eight *i.e*. JS 20-69, JS 20-57, JSM 222, AMS 2014-1, MACS 1407, PS 1225, PS 1611, Cat 330 and seven *i.e*. JS 20-96, JSM 126, DCB 137, SL 900, JS 20-98, JS 20-116, Cat 2126 B reacted as absolute and highly resistant, respectively (Table 2). The other genotypes were found to be moderately resistant (58), moderately susceptible (38) and susceptible (10). In checks, JS 93-05 was most affected with 53.5 per cent severity. Previously, Gawade *et al*. (2009) evaluated 184 genotypes of soybean and none was found to be highly resistant against Anthracnose. Shrirao *et al*. (2009) found absolute and highly resistant genotypes and Sajeesh *et al*. (2014) reported moderate resistant in most of the genotypes (64 per cent) against anthracnose and pod blight.

Resistance to both diseases

In one hundred twenty one, only five genotypes namely JS 20-57, JSM 222, MACS 1407, PS 1611, Cat 2126 B were found to be highly resistant against both diseases aerial

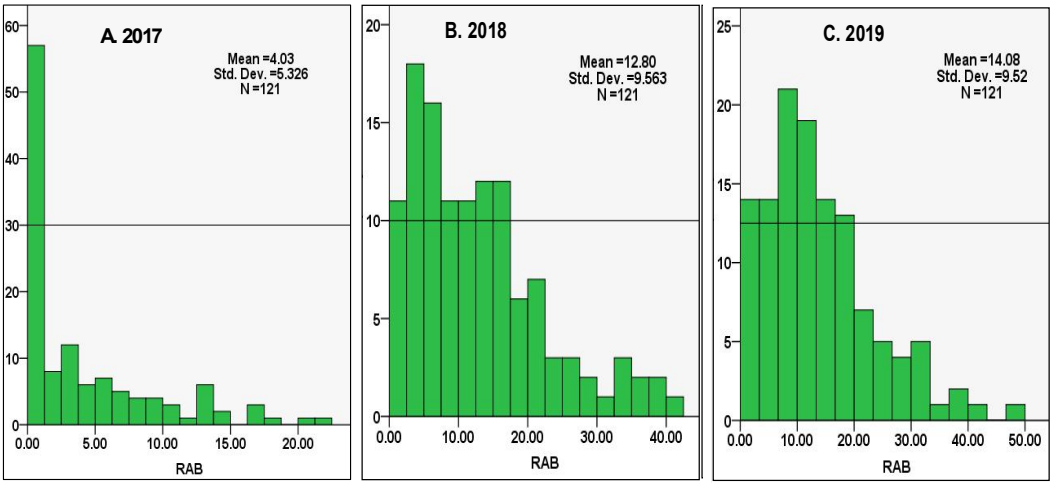


Fig 3: Frequency distribution of genotypes based on Rhizoctonia Aerial Blight (RAB) severity during (A) 2017, (B) 2018 and (C) 2019, respectively.

Table 1: Reaction of soybean genotypes based on average of two highest per cent disease index (PDI) of Aerial blight during 2017, 2018 and 2019.

Reaction	PDI	Soybean genotypes	Total
Absolutely resistant	0	-	0
Highly resistant	0-1	JS 20-30, JS 20-57, JSM 222, MACS 1407, PS 1611, Cat 2126 B	06
Moderately resistant	>1 to 10	JS 20-61, JS 20-81, JS 20-96, JS 20-104, JS 20-24, JS 20-36, JS 20-69, JS 20-34, JS 20-18, JS 20-20, JS 20-23, JS 20-25, J S 20-48, JS 20-94, JSM 283, JSM 126, DCB 137, AMS 77, AMS 358, AMS MB 5-18, AMS 2014-1, AMS 264, DS 3106, KDS 1009, KDS 921, MACS 450, MACS 1520, MACS 1370, MACS 1493, MAUS 162, RSC 10-52, RSC 11-03, NRC 124,NRC 84, NRC 133,NRC 71, SL 955, RKS 66, PS 1469, PS 1225, RVS 2010-2, NRC 86, JS 20-98, JS 20-116,CAT 489 A, Cat 2114 A, Cat 330, Cat 1328, BR 14, B 327	50
Moderately susceptible	>10 to 25	JS 20- 74, JS 20-110, JS 20-37, JS 99-77, JS 20-82, JS 20-73, JS 20-67, JS 20-78, JS 20-59, JS 20-56, JS 20-75, JSM 301, JSM 302, JSM 149, JSM 245, DSb 32, AMS 4873, AMS 56, AMS 38-24, AMS 243, AGS 48,IA 1025, MAUS 706, MAUS 158, MAUS 71,DS 3104, KBS 1045, RSC 10-46, NRC 129, NRC 136, SL 983, SL 900, SL 96, RKS 113, RKS 45, PS 1589, PS 1613, RVS 2001-04, RVS 2001-18, RVS 2009-9, RVS 2011-4, RVS 2011-1, RVS 2007-06, RVS 2010-1, RVS 2011-12, VLS 94, NRC 37, JS 97-52, Cat 2503,Cat 1857, JS 93-05 (c), JS 335 (c), JS 72-280 (c), Punjab 1 (c)	54
Susceptible	>25 to 50	JS 75-46, AGS 112, AGS174, AMS 475, ERS 0757, ERS 9045, RKS 24, BRG 1, Cat 408, VLS 58 (c), RKS 18 (c)	11
Highly susceptible	> 50	-	0
			121

Table 2: Reaction of soybean genotypes based on average of two highest per cent disease index (PDI) of anthracnose/pod blight during 2017, 2018 and 2019.

Reaction	PDI	Soybean genotypes	Total
Absolutely resistant	0	JS 20-69, JS 20-57, JSM 222, AMS 2014-1, MACS 1407, PS 1225, PS 1611, Cat 330	08
Highly resistant	0-1	JS 20- 96, JSM 126, DCB 137, SL 900, JS 20-98, JS 20-116, Cat 2126 B	07
Moderately resistant	>1 to 10	JS 20-61, JS 20-81, JS 20- 104, JS 20-36, JS 20-18, JS 20-23, JS 20-25, JS 20-30, JS 99-77, JS 20-59, JS 20-48, JS 20-56, JS 20-94, JS 20-82,JSM 283, JSM 301, JSM 302, AMS 56, AMS 38-24, AMS 77, AMS 243, AMS MB 5-18, AGS 112, AGS 48, DS 3106, KDS 1009,MACS 1520, MACS 1370, DS 3104, MAUS 162,MAUS 71, MAUS 158, RSC 10-46, RSC 11-03, NRC 124, NRC 129, NRC 136, NRC 71, NRC 84, SL 983, SL 955, SL 96, RKS 66, RKS 45, PS 1589, PS 1613, PS 1469, RVS 2001-04, RVS 2009-9, RVS 2007-06, RVS 2011-12, RVS 2010-2, NRC 86, JS 97-52, Cat 2114 A, Cat 2503, BRG 1, B 327	58
Moderately susceptible	>10 to 25	JS 20- 74, JS 20-110, JS 20-37, JS 20-24, JS 20-75, JS 20-34, JS 20-20, JS 20-73, JS 20-67,JS 20-78, JS 75-46, DSb 32, AMS 264, AMS 475, KDS 921, MAUS 706, MACS 450, MACS 1493, ERS 9045, RSC 10-52, NRC 133, RKS 113, RKS 24, RVS 2001-18, RVS 2011-4, RVS 2010-1, RVS 2011-1,VLS 94, NRC 37, CAT 489 A, Cat 408, Cat 1328, BR 14, VLS 58 (c), JS 335 (c), JS 72-280 (c), Punjab 1 (c), RKS 18 (c),	38
Susceptible	>25 to 50	JSM 149, JSM 245, AMS 4873, AMS 358, AGS174, IA 1025,ERS 0757, KBS 1045, Cat 1857,JS 93-05 (c)	10
Highly susceptible	>50	-	0
			121

blight plus anthracnose/pod blight (Table 3). Whereas only one genotypes (JS 20-30) was found to be highly resistant (aerial blight) + moderately resistance (anthracnose/pod blight) and nine (JS 20-69, AMS 2014-1, PS 1225, JS 20-96, JSM 126, DCB 137, JS 20-98, JS 20-116, Cat 330) were also reacted as highly resistant (anthracnose/pod blight) + moderately resistance (aerial blight), respectively.

Yield loss due to aerial blight and anthracnose/pod blight

The results revealed that each variety were responded differently in term of per cent pod and yield losses at different level of severity of aerial blight and anthracnose/pod blight in soybean during 2018 and 2019 (Fig 5 and 6). Both the disease reduced pod and yield significantly in all the varieties (Table 4). In case of aerial blight, per cent pod and yield

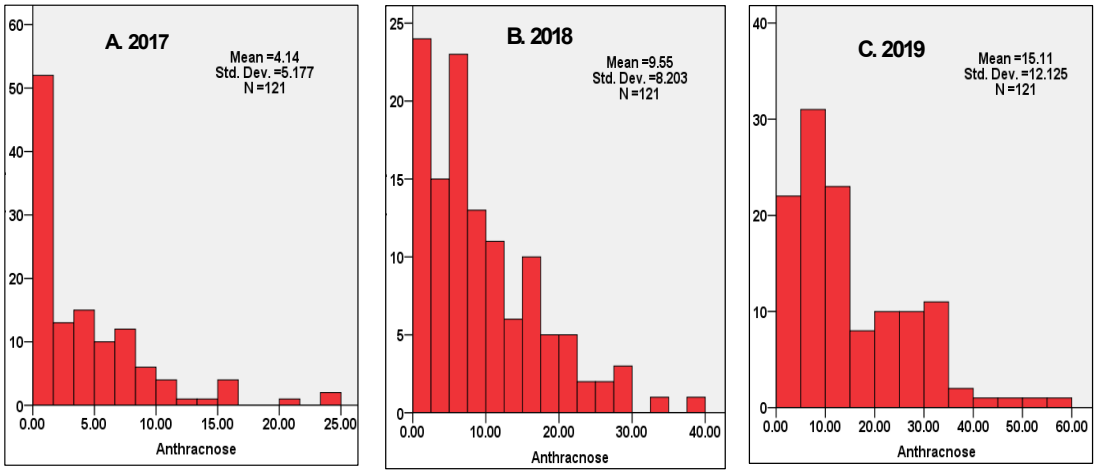


Fig 4: Frequency distribution of genotypes based on Anthracnose/pod blight severity during (A) 2017, (B) 2018 and (C) 2019, respectively.

Table 3: Soybean genotypes exhibiting dual resistances against Aerial blight and Anthracnose/pod blight.

Diseases	Absolute /Highly resistant lines	Total
HR (Aerial blight+ Anthracnose/pod blight)	JS 20-57, JSM 222, MACS 1407, PS 1611, Cat 2126 B,	05
HR (Aerial blight) + MR (Anthracnose/pod blight)	JS 20-30	01
HR (Anthracnose/pod blight) + MR (Aerial blight)	JS 20-69, AMS 2014-1, PS 1225, JS 20-96, JSM 126, DCB 137, JS 20-98, JS 20-116, Cat 330	09

Table 4: Summary of per cent pods and yield losses due to Aerial blight and Anthracnose/pod blight diseases in soybean during 2018 and 2019 (pooled).

Varieties	Healthy plant		Aerial blight			Anthracnose and pod blight		
	Pods	Yield (g)	PDI	% pod loss	% yield loss	PDI	% pod loss	% yield loss
JS 93-05	20.7	5.2	28.9	6.7	14.1	75.2	39.4	64.8
JS 335	26.2	5.8	39.9	14.2	24.7	42.4	7.9	27.8
JS 72-280	27.1	4.6	44.4	24.4	30.6	38.2	14.8	28.8
Punjab 1	19.7	4.3	40.5	17.2	23.9	24.7	5.1	13.6
RKS 18	20.0	4.1	55.6	30.7	41.0	36.6	9.9	24.2
VLS 58	20.8	4.1	45.0	19.3	29.5	34.9	8.8	22.7
CD (p=0.05)	3.12	0.68	5.41	3.00	2.89	6.36	3.14	5.15

PDI = Per cent disease index.

Table 5: Correlation coefficient between disease severity and corresponding per cent pods and yield losses.

Year	Aerial blight		Anthracnose and pod blight	
	% pod loss	% yield loss	% pod loss	% yield loss
2018	0.892*	0.988**	0.946**	0.992**
2019	0.982**	0.987**	0.944**	0.989**
Pooled	0.966**	0.995**	0.957**	0.995**

*= Significant (p=0.05), **= Highly significant (p=0.01).

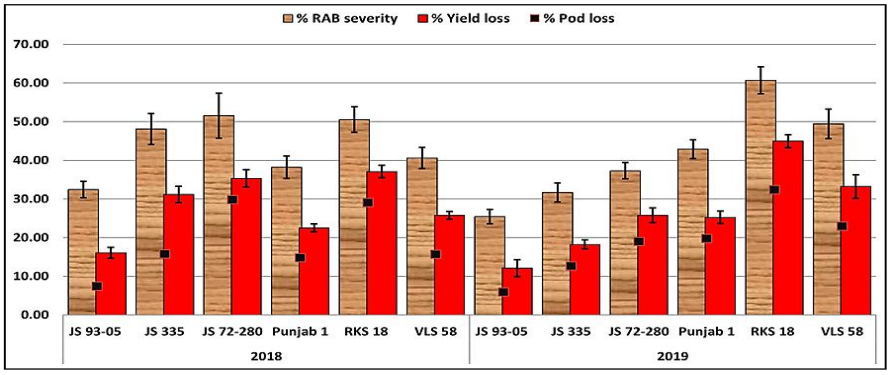


Fig 5: Variety wise Rhizoctonia Aerial Blight severity (RAB) and corresponding per cent pods and yield losses in soybean during 2018 and 2019.

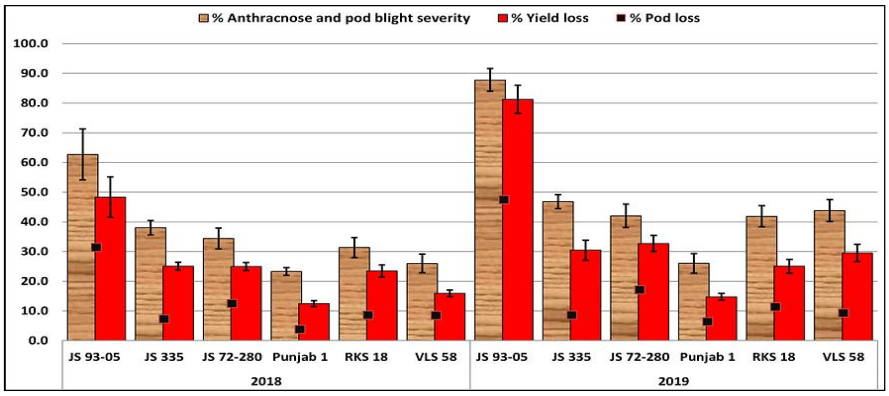


Fig 6: Variety wise Anthracnose/pod blight severity and corresponding per cent pods and yield losses in soybean during 2018 and 2019.

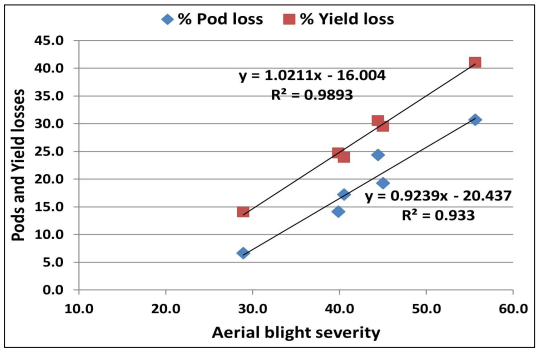


Fig 7: Overall relations of per cent Aerial blight severity and per cent pods and yield losses in soybean.

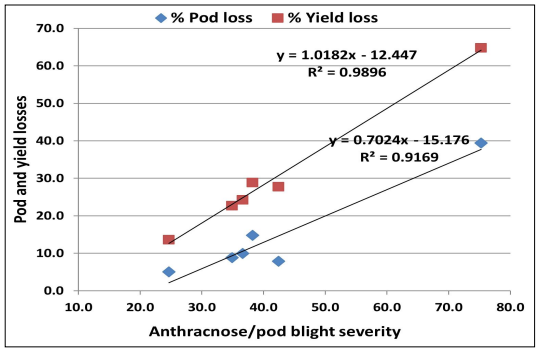


Fig 8: Overall relations of per cent Anthracnose/pod blight severity and per cent pods and yield losses in soybean.

losses were ranged from 6.7 to 30.7 and 14.1 to 41.0, respectively as against 28.9 (in JS 93-05) to 55.6 (in RKS 18) per cent severity at 90 days old crop. Whereas, in case of anthracnose/pod blight per cent pod losses was found to be little as comparison to aerial blight in most varieties. The highest pod (39.4 per cent) and yield (64.8 per cent) losses were recorded in JS 93-05 on 75.2 per cent severity of anthracnose/pod blight at 90 days old crop. Severity of RAB and Anthracnose was highly significantly correlated with per cent pod (0.966** and 0.957**) and yield (0.995** and 0.995**) losses, respectively (Table 5). Linear regression equations (Fig 7 and 8) for yield reduction from aerial blight ($y = 1.021x-16.00$, $R^2 = 0.989$) and anthracnose/pod blight ($y=1.018x-12.44$, $R^2 = 0.989$) revealed that both the disease can cause huge yield losses at high level of severity and one unit increase in the severity may cause almost one unit yield loss in soybean. In previous findings, Fenille *et al*. (2002) also reported 31-60% yield loss in North and Northeast Brazil due to RAB and Stetina *et al*. (2006) also reported pod loss in aerial blight infection and found significant positive correlation between foliar blight and pod losses. Backman *et al*. (1982) reported 16 to 26% seed yield loss due to anthracnose in the southern area of the United States. Sharma *et al*. (2011) found no or few seed formation in soybean in case of early stage infection of anthracnose.

CONCLUSION

The study concluded that most of the evaluated soybean genotypes were moderately resistant to moderately susceptible against aerial blight and anthracnose/pod blight. Only five genotypes namely JS 20-57, JSM 222, MACS 1407, PS 1611, Cat 2126 B were found to be highly resistant against both the diseases. These identified genotypes may further be utilized in resistance breeding programme and for confirmation of resistance at molecular level. It has also revealed that pod and yield losses increased with severity of aerial blight and anthracnose/pod blight. Early infection coupled with high severity of any, aerial blight or anthracnose/pod blight, disease could result in huge yield reduction in soybean.

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REFERENCES

Agarwal, D.K., Billore, S.D., Sharma, A.N. (2013). Soybean: Introduction, Improvement and Utilization in India-Problems and Prospects. Agricultural Research. 2: 293-300.

Amrate, Pawan K., Pancheshwar, D.K. and Shrivastava, M.K. (2018). Evaluation of soybean germplasm against charcoal rot, aerial blight and yellow mosaic virus disease in Madhya Pradesh. Plant Disease Research. 33(2): 185-190.

Amrate, Pawan K., Shrivastava, M.K. and Singh, G. (2020). Screening of genotypes to identify the resistance source against major diseases of soybean under high disease pressure conditions. International Journal of Current Microbiology and Applied Sciences. 9(5): 1739-1745.

Anonymous, (2018). Director's Report and Summary Tables of Experiments. All India Coordinate Research Project on Soybean, ICAR-Indian Institute of Soybean Research. p 327.

Anonymous, (2012). In: Proceedings and Technical Programmes (2012-13) of 42nd Annual Group Meeting CSK Himachal Pradesh Krishi Vishwavidyalaya, Palampur (Himachal Pradesh) March 22-24, 2012, 68 pp.

Backman, P.A., Williams, J.C. and Crawford, M.A. (1982). Yield losses in soybeans from anthracnose caused by *Colletotrichum truncatum*. Plant Disease. 66: 1032-1034.

Dupare, B.U, Billore, S.D., Sharma, A.N. and Joshi, O.P. (2014). Contribution of area, productivity and their interaction towards changing oilseeds and soybean production scenario in India. Legume Research. 37(6): 635-640.

Fenille, R.C., Souza, N.L.D. and Kuramae, E.E. (2002). Characterization of *Rhizoctonia solani* associated with soybean in Brazil. European Journal of Plant Pathology. 108: 783-792.

Gawade, D.B., Suryawanshi, A.P., Patil, V.B., Zagade, S.N. and Wadje, A.G. (2009). Screening of soybean cultivars against anthracnose caused by *Colletotrichum truncatum*. Journal of Plant Disease Science. 4: 124-125.

Jones, R.K. and Belmar, S.B. (1989). Characterization and pathogenicity of *Rhizoctonia* spp. Isolated from rice, soybean and other crops grown in rotation with rice in Texas. Plant Disease. 73(12): 1004-1010.

Manandhar, J.B. and Hartman, G.L. (1999). Anthracnose. In: Compendium of Soybean Diseases. [G.L. Hartman, J.B. Sinclair and J.C. Rupe (eds.)], American Phytopathological Society, St. Paul, MN. Pages 13-14.

Mathpal, M. and Singh, K.P. (2017). Prevalence and severity of Rhizoctonia aerial blight of soybean in Uttarakhand. Indian Journal of Ecology. 44(2): 417-419.

Mayee, C.D. and Datar, V.V. (1986). Phytopathometry Technical Bulletin-1 (Special Bulletin-3). Marathwada Agricultural University, Parbhani. pp 34-37.

Patel, K. (2011). Studies on *Rhizoctonia aerial* blight with special reference to identify the source of resistance in soybean [*Glycine max* (L) Merrill]. M.Sc. Thesis, J.N.K.V.V. Jabalpur.

Sajeesh, P.K., Rao, M.S.L. and Jahagirdar, S. (2014). Screening of soybean [*Glycine max* (L.) Merill] genotypes against purple seed stain and anthracnose diseases. Environment and Ecology. 32(3A): 1092-1095.

Sharma, S.K., Gupta, G.K. and Rajkumar, R. (2011). *Colletotrichum truncatum* (Schw. Andrus and W.D. Moore) the causal agent of anthracnose of soybean [*Glycine max* (L.) Merrill]-A review. Soybean Research. 9: 31-52.

Sharma, P., Dupare, B.U. and Patel, R.M. (2016). Soybean improvement through research in India and socio-economic changes. Legume Research. 39(6): 935-945.

Shrirao, A.V., Gawade D.B., Shrirao, R.A., Patil S.P. and Khote, A.C. (2009). Evaluation of soybean genotypes against the major disease. Journal of Plant Disease Science. 4(1): 92 -94.

Sinclair, J.B. and Shurlieff, M.C. (1975). Compendium of soybean disease, American Phytopath. Soc. Inc. Minnesota. USA: 8-10.

SOPA (2020). The Soybean Processors Association of India (SOPA) report http://www.sopa.org/statistics/world-soybean-production/

Stetina, K.C., Stetina, S.R. and Russin, J.S. (2006). Comparison of severity assessment methods for predicting yield loss to Rhizoctonia foliar blight in soybean. Plant Disease. 90: 39-43.

Wan, Gyu Kim, Sung, Kee Hong, Seong, Sook Han (2005) Occurrence of web blight in soybean caused by *Rhizoctonia solani* AG-1(IA) in Korea. Plant Pathology Journal. 21(4): 406-408.

Wheeler, B.E.J. (1969). An Introduction to Plant Diseases. John Wiley and Sons Ltd., London. 301 pp.

Williamson, M.R., Rothrock, C.S. and Muellar, J.D. (2006). First report of foliar blight of soybean in South Carolina. Plant Health Progress. 3: 1-3.

Wrather, A., Shannon, G., Balardin, R., Carregal, L., Escobar, R., Gupta, G.K., Ma, Z., Morel, W., Ploper, D. and Tenuta, A. (2010). Effect of diseases on soybean yield in the top eight producing countries in 2006. Online. Plant Health Progress doi: 10.1094/PHP-2010-0125-01-RS.

Wrather, J.A. and Koenning, S.R. (2006). Estimates of disease effects on soybean yields in the United States 2003 to 2005. Journal of Nematology. 38: 173-180.

Yang, X.B., Snow, J.P. and Berggren, G.T. (1990). Analysis of epidemics of Rhizoctonia aerial blight of soybean in Louisiana. Phytopathology. 80: 386-392.