Charcoal Rot of Soybean: A Review

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Abstract

Soybean rank first as a source of vegetable oil global area and production of soybean 120.81 and 338 million tons respectively and in India it is cultivated in 10.50 m ha. So it's an important crop under consideration when it comes to legumes because there are many more reasons for its consideration, such as soybean contains 38-40% of protein which is 3times more than eggs and 12 times more than milk and oil content accounts for 50-56% it has many health related benefits. Besides above description soybean plays as a main role for supply of raw material for industries like livestock feed,soy milk industries, tofu , soy nut etc. but this crop is attacked by many fungal bacterial and viral diseases reducing yield in India and causing major economic losses to the farmers and stagnating industrial requirement for raw material. Mainly Yellow Mosaic Virus (YMV),charcoal rot(*Macrophomina phaseolina*),anthracnose (*Colletotrichum truncatum*)how these diseases entered in India and what are the effects caused on plant which deteriorate the grain quality reducing oil content and protein content,way of spreading ,primary identification, introduction of breeding methodsand resistant variety, to solve the problems, estimation on how the intensity of the above mentioned disease increases in future and its counterpart on plant disease intensity by conventional and genetic methodology

Key words:- Yellow mosaic virus, charcoal rot,Anthracnose, plant disease intensity, genetic methodology, resistant varieties

First diseases observed in India

Yellow mosaic virus: - In AUGUST 2005 it was observed in National Botanical Research Institute, Lucknow and earlier it was confused by bigmovirus but when it was tested experimentally by using whiteflies as vectors and when the isolated DNA from samples shown its similarity with cotton leaf curl kokharn virus (CLCKV) at 95% match than Mungbean yellow mosaic India virus(MYMIV) then it was considered that this diseases on soybean earlier was from northern India (Usharani et al., 2004) fig.1&2.

Charcoal rot: -*M.phaseolina* is a polyphagous fungi the abundant sclerotia produced gives appearance of blacken tissue hence this disease is named as charcoal rot (Sarr et al., 2014) The charcoal rot disease of soybean was first confirmed in Minnesota in north east Dakota(Dean maverick 2018) and later they found it can spread to corn and sunflowerand it was reported as an fungal disease, it deteriorate seed quality and many quarantine issues would be raised in India. This disease accounts for 19.02% of losses followed by anthracnose and YMV fig.3&4. Where YMV and charcoal rot are the serious problems in India causing major losses in yield, after YMV, charcoal rot is most epidemic disease effecting its production and quality in India.

Yellow mosaic virus in soybean

Figure1. YMV on leaf

Figure 2. Effect of YMV on seeds resulted mottling

Charcoal rot in soybean

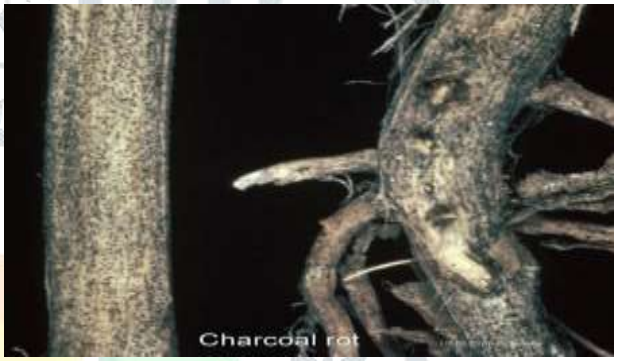

Figure 3. (*Macrophomina spp*) sclerotia in stem and root tissue

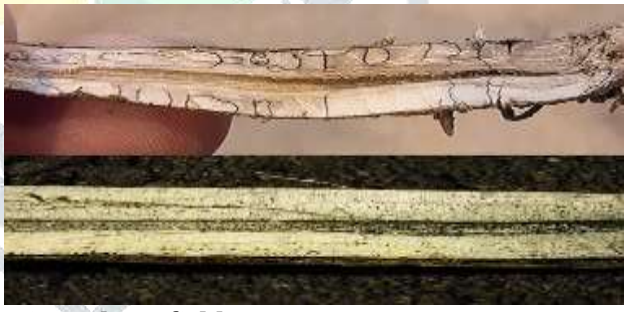

Figure 4. Charcoal rot in soybean field

Yield losses in world due to charcoal rot in soybean

Table 1: Estimated decrease of yield (thousand MT) due to the following diseases in soybean producing country in 2006 (Wrather et al., 2008).

Diseases	Argentina	Bolivia	Brazil	Canada	China	India	Paraguay	USA	Total
VXY	45.3	Trace	100	9.8	1568.5	196.1	0	202.7	2,122.4
Charcoalrot	905	500	360	1.6	0	39.2	1.6	697.6	2,505
Pod and stem blight	181	0	0	11.4	95.1	19.6	0.1	208.3	515.5
Total	1131.3	500	460	21.9	1663.6	254.9	1.7	1108.5	5142.9

- Vxy- YMV including other virus causing diseases

Disease life cycle in charcoal rot and YMV

Yellow Mosaic Virus (YMV)

This disease is transferred through white flies which suck the plant sap and this disease has wide host plant range including weeds and pulse crops.

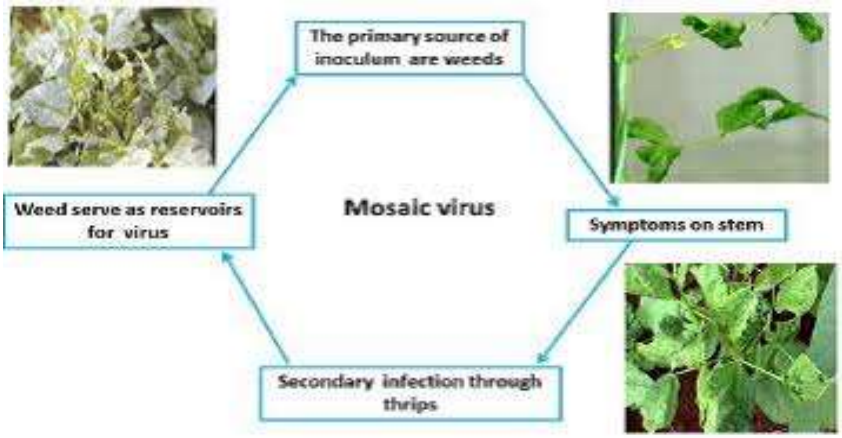

Figure 5. Cycle of YMV

A-overwintering of sclerotiana
B-infected roots when contacted with sclerotiana
C-fungus grown in vascular tissue of roots and stems
D-abundant microsclerotia presence in lower stems

Macrophomina phaseolina survive as hard structures in soil called micro sclerotia these sclerotia can infect the root tissue these sclerotia has capability to infect the young seedlings and mature cells and they can survive in soil for 2 years they can infect the vascular system and intefer in normal plant functions such as water transportation. (Gupta and chauhan et al., 2005) wilt symptoms.

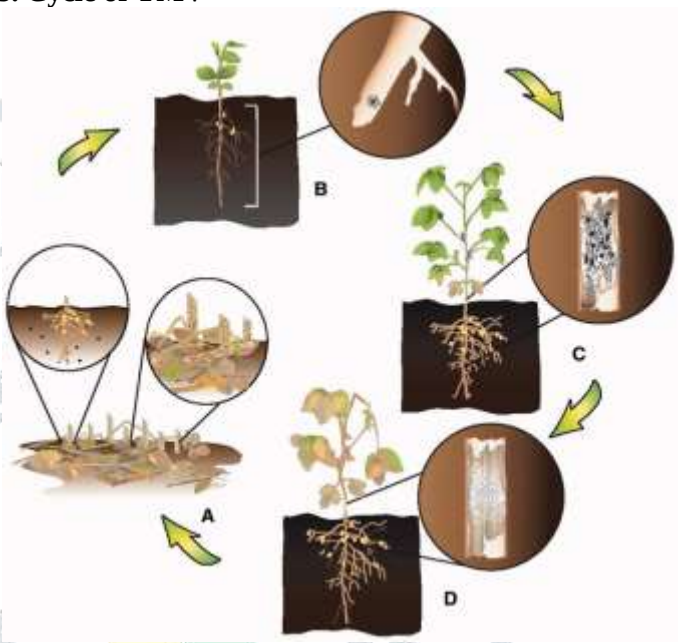

Figure 6. Cycle of charcoal rot (Smith et al., 2014)

Symptoms ofYMV and charcoal rot: - The following table gives in detail about the disease symptoms.

YMV	Charcoal rot
Green and yellow patches was found on younger leaves • Fewer flowers and pods • Small seeds • Mottled seed appearance Decrease in both quality and quantity in terms of yield	Disease can be occurred at early stages such as seedling still it don't show any observable symptoms 'the symptoms can be seen in maturity beginning • Yellow leaves • Reduced vigour • General wilting appearance • Brown to red discoloration of roots(Wrather et al., 2008) • Premature senescence on foliar leaves • Premature plant death • Deteriorate quality and yield (Smith and Wyille et al., 1999)

Screening for resistance in charcoal rot in soybean

Field screening

Earlier screening was focused in root zone of *M.phaseolina* colonies but after that (Smith and carvil1997) discovered CFU means Colony Forming unit assay and from it sclerotia is quantified from its root and the above method consists of collecting taprootand lower parts of stem of randomly selected plants and field of planting,desiccated samples on media. Even so these results in variable and inconsistency among studies then CFU method is considered as standard method for resistance screening. Samples are collected on sterilized PDA,rifampicin,tergitol, incubated 3 days at 30^0C. After three days counting and conversion of CFU into grams from stem colonization and (Mengistu et al., 2011b)after obtaining itevery genotype by dividing CFU for every genotype fig.7.

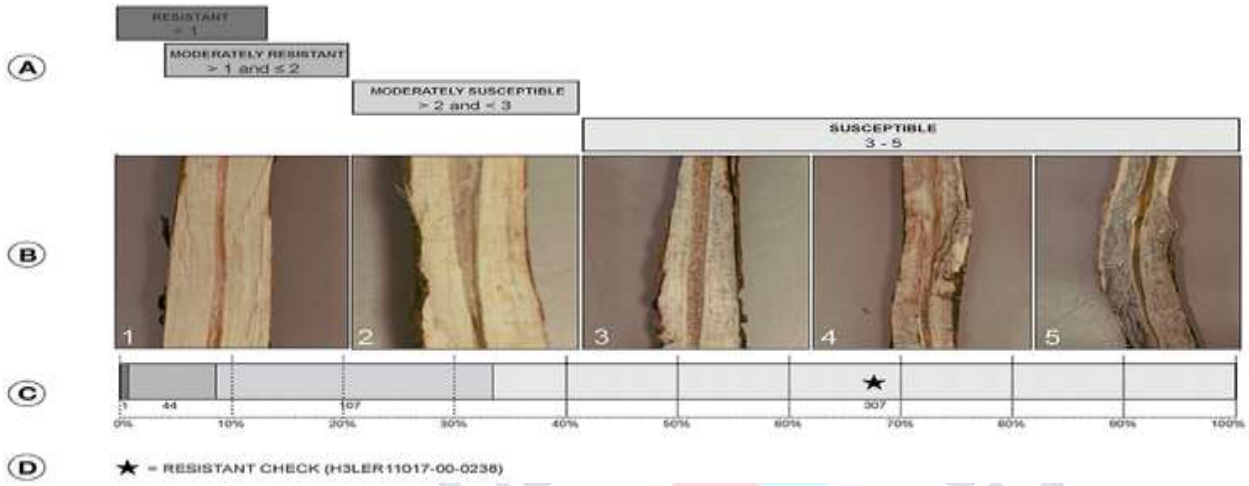

Figure 7. Classes of charcoal rot resistance(Field screening)

Screening in green house

Cut stem inoculation method: Cut stem is inoculated fig.8 and evaluated under greenhouse based on the necrosis intensity on each plant and this method became easy to know the intensity of disease in each plant and disease intensity is measured at plant presents inoculums point this technique helped to quantify the inoculums for every plant should be tested accurately or precisely and it is also less time consuming method of measuring disease intensity. So for this method is used for the identification of the susceptible and the resistant genotypes for charcoal rot(Twizeyimana et al., 2012).

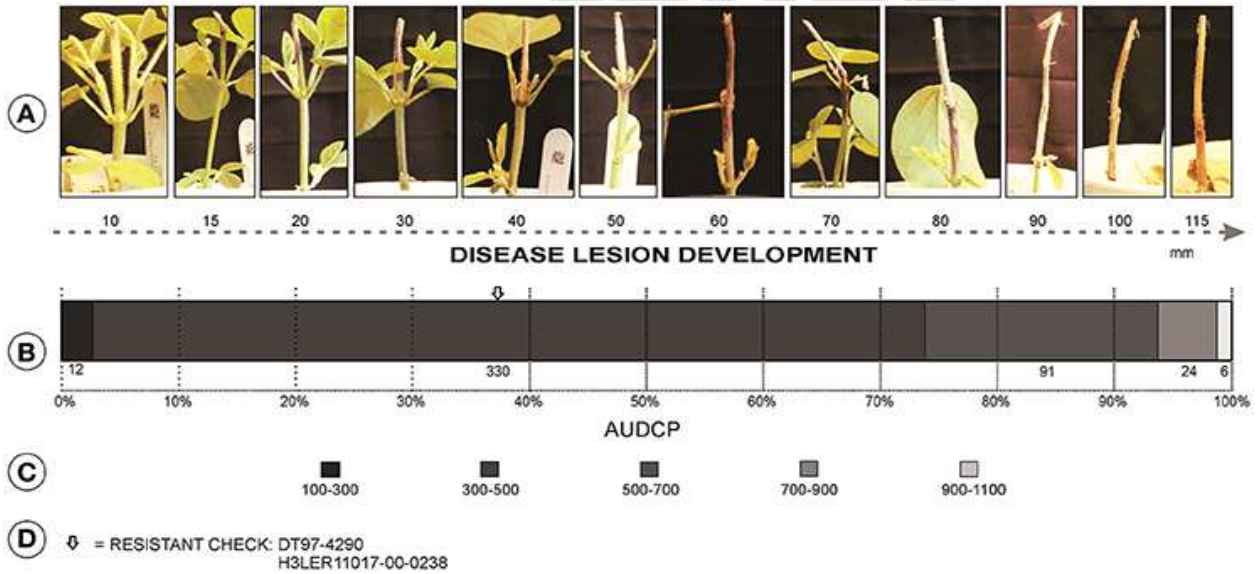

Figure 8. Measurement of lesion length (Pawlowski et al., 2015) (Screening in green house)

QTL studies on soybean genome for resistant of charcoal rot

When the soybean genome was sequenced (Schmutz et al., 2010)but the information of charcoal rot was not found, even when QTL studies or genome wide association mapping has done for charcoal rot in soybean research, but only on *Phaseolus vulgaris*. It was identified 3 novel QTLs and one QTL for charcoal rot resistance (Hernandez-delgade et al., 2009), respectively. A series of research is needed to get information for breeders to develop soybean genotypes with good range of charcoal rot resistance allelesthat can be merged and average resistant genotypes with improving drought tolerance through genetical concept application could also provide new outcomes for minimizing charcoal rot. Combination with the sum of common and traditional screening methods (Sexton et al., 2016)itwould increase the resistance to charcoal rot.

Resistant varieties of soybean on charcoal rot

Moderately resistant variety available for sowing

Genotype	Maturity group	Reference
DG3905	3	Mengistu et al.,2011b
Manokin	4	Mengistu et al., 2011b
DT97-4290	4	Paris et al.,
DT99-4290	5	Mengistu et al.,2007 Mengistu et al.,2011b Gillen et al.,2016
DT99-17483	5	Mengistu et al.,2007 Mengistu et al.,2011b
DT98-7553	5	Mengistu et al.,2007 Mengistu et al.,2011b
DT99-17554	5	Mengistu et al.,2007 Mengistu et al.,2011b

Control on genotyping and quality

In field screening out of 459 genotypes 155 (34%) expressed better resistance for charcoal rot then resistant checks and for greenhouse screening 30 out of 459 (7%) then checks the following table shows top genotypes with better charcoal resistance.

Genotypes	Field rating	(AUDPC) Greenhouse rating
PI567241	3.6	351.2
PI549064	3.0	352.2
PI379559D	2.1	356.6
PI091725	2.8	360.2
PI471899	2.9	360.9
PI603594	2.3	361.2
PI437462A	3.8	363.6
PI567774B	3.8	364.9
PI084973PI079694	3.8	366.8
PI232928	2.5	371.9
PI096322	3.9	372.1
PI404169B	3.4	372.9
PI567250B	3.2	374.4
PI5744788B	3.3	375.0
Disease resistant checks	Field	Greenhouse
DT97-4290	-	392.2
H3LER11017-00-0238	4.0	427.0

*AUDPC- (Area under Disease Progress Curve) it is used for green house data (Jeger et al., 2001)

Overall recommendation for management and future research requirements on soybean charcoal rots

The farmer having fields with incidence of charcoal rot should follow the integrated methods for the effective control and areas in danger of getting charcoal rot development should select genotypes or the variety with the good available maximum promising resistance. Agronomical management practice that will reducestress on plant during the flowering stagewhich would help to mitigate damage of charcoal rot. Sowing at required spacing with recommended plant population using needed cultural practice in controlling weeds, irrigation were possible help in the coming severe stress in soybean and reduce the impact of*M. phaseolinain* series (Smith et al., 2014).

Continuous research in*M.phaseolina* with management practices will develop in further generationsas there has been foremost in understanding the importance of resistance gene in expression of cultivar resistance,molecular interaction between the plant and the infective pathogen and a good in knowing the role of environment in disease growth. This contentwillenhance ourcapacity to screen for moderately or highly resistant varietiesin maturity classes adapting to every place which should be wide and adaptable.

Important highlights of soybean charcoal rot

Basically this disease was observed in southern part of USA later on it has spread to the northern part of USA due to the hot and dry conditions for years (Romero lunna et al., 2017) it was spreading in all northern part of USA but it was first observed in Minnesota (Elaraby et al., 2003), Michigan (Baird et al., 2010).

Conclusion

By enhancing the knowledge on this disease we can reduce its effect on soybean as it has hundreds of races it can break the resistant barriers in varieties. As resistance, there is no complete resistance found for this disease till now as the disease resistance is quantitatively expressed present research is to use the genomic technique to identify for greenhouse screening P450 gene on chromosome 6 found to be resistant for both charcoal rot and rust including cyst nematode

It’s an assumption that Charcoal rot also plays an important role in human infection when the infected seeds of soybean are consumed particularly in immune suppressed patients. The infection may present as acutaneous cellulities or as an ocular keratits

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