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Impact of Land and Water Management practices on Root Rot Complex influencing Lentil performance

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ABSTRACT

Lentil plays a pivotal role in food and nutritional security of vegetarian sector of India. Root rot complex of lentilis a sever disease with a potential to devastate entire crop. An invstigation was undertaken to study the dynamics of root rot in rice - lentil – mungbean cropping systems under conventional and zero tilled conditions with 04 water regime based on IW:CPE, at ICAR-Research Complex for Eastern Region, Patna, Bihar, India during 2016-17 to 2018-19. Rhizoctonia solani and Fusarium oxysporum were the fungus responsible for root rot incidence. Results reveled that the disese incidence percentage is more with 65% yield penalty and the maximum will be more than 80% as compare to the normal crop. Root rot complex can damage more at advanced stage as compare to seedling or early groth stages. Best way to manage root rot disease complex are adapting crop rotation, sowing resistance varieties along with prophylactic seed treatment.

KEYWORDS

Fusarium oxysporum, Land and water management, Lentil, *Rhizoctonia solani*, Root rot complex, Yield penalty, ETL

INTRODUCTION

Lentil (*Lens culinaris*) is one of the most adaptive yet important winter season food legumes on the planet earth, used as grain or green for various culinary purposes (Singh *et al.*, 2018). The chief source of dietary protein for majority vegetarian Indian, are legumes. Legumes contribute significantly to the nutritional security of the country. India is the largest producer, consumer, importer and processor of pulses. Globally, top lentil producers are Canada, India, Turkey and United States. Canada is the leading lentil exporting country. India ranks first in the area and second in production with 35.57% and 23.94% of world area and production, respectively with the productivity of 697 kg/ha well below the world average(1103 kg/ha). It is grown by 1.47 million ha with a total production of 0.99 million tones. Uttar Pradesh is the major contributor sharing half of the total lentil production followed by Madhya Pradesh (Singh *et al.*,2018).

Due to complimentary ambient atmospheric as well as rhizosphere environment and their interaction soil-borne pathogens' population buildup gradually below the plough region. Over a period of time in long run if legume crops are grown for long time on same piece of land (Singh *et al.*,2014). Soil-borne pathogens are capable of invading the legume plant right from seedling to podding stage. Root rot disease is caused by Rhizoctonia solani and Fusarium oxysporum f. sp. lentis, commonly termed as root rot complex, is one of the most serious disease of pulse crops (Ajayi *et al.*,2013; Díaz-Arias *et al.*,2011; Lops *et al.*,2013). Soil moisture plays an important role in root-associated pathogen population dynamics especially root rot incidence of lentil. Rhizoctonia bataticola, Rhizoctonia solani, Fusarium oxysporum f. sp. lentis, S. rolfsii and Alternaria sp. are reported to infect at all moisture levels. Higher population of Fusarium oxysporum f. sp. lentis is favored by lowr moisture availability while high soil moisture content favors Rhizoctonia solani and Rhizoctonia bataticola (Chaudhary *et al.*,2009). However, high temperature coupled with soil moisture deficit predisposes pulses to R. bataticola infection, colonization and development (Sharma and Pande, 2013).

Soil compaction and warmer soil temperatures favor the development of Fusarium root rot throughout the growing season (Mamta and Pande, 2013). Symptoms appear as yellowing and sudden drying of whole plants. The taproot becomes dark brownand brittle in dry soil with extensive root rot and loss of lateral roots. When the diseased plant is uprooted, lower portion of the taproot remains detached in the soil. Symptoms of Rhizoctonia solani appears as poor emergence, reddish-brown to dark brown sunken lesions on roots and base of stem, Secondary roots absent, plants are stunted, leaves turn yellow and finally senescence occurs. The severity of disease incited by Fusarium on lentil has been variable, ranging from 25% mortality at seedling stage (Kannaiyan *et al.*,1972) to 50% mortality at flowering and pod setting stage (Khare *et al.*,1972).

Under the project "Improve rice-lentil-mung bean system productivity through land and water management" an investigation was undertaken from 2016-17 to 2018-19. In this experiment two levels of land management i.e. Conventional tillage (CT) and conservation tillage (ZT), along with 04 water management level

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(Irrigation at IW: CPE) was applied and was tested under cropping system mode. During third cropping cycle root rot buildup starts taking place since seedling stage, suggest and confirm that due to gradual buildup over the period and severe infestation of Fusarium oxysporum and Rhizoctonia solani, causing very poor plant stand due to heavy mortality resulting poor biological and economic yield.

Lentil (Lens culinaris) cultivar HUL 57 was grown as per the technical program under zero tillage and conventional tillage system. The study was conducted under the project 'Improving rice – lentil - mung bean system productivity through land and water management' during 2016-17, 2017-18 and 2018-19 at main campus experimental fields of ICAR-Research Complex for Eastern Region, Patna 25°35'N latitude and 85° 05'E longitude), Bihar, India.

Experimental design

The experimental plot was of 7.0 m x 5.0 m size. All the agronomic management practices were as per the recommended standard. Soil sampling was done for each plot before the onset of experiment and after completion of each crop cycle as per the standard procedure described by AOAC (1980) . The soil texture of experimental plot was silty clay loam with pH 7.1; electrical conductivity 0.17 ds/m (in 1:2 soils: water solution); with organic carbon 0.69 per cent, available nitrogen 261.7 kg/ha, available phosphorus 33.1 kg/ha, available potash 211.4 kg/ha, sulphur 9.3 kg/ha and zinc 1.2kg/ha. The soil was of silty clay loam type with medium soil fertility status.

Treatments details

In this experiment two types of land management i.e. Conventional tillage (CT) and conservation tillage (ZT), along with 04 water management level (irrigation at IW: CPE) is being tested under rice-lentil- mung bean cropping system. Four treatments were taken like T_1= W_1 (Rainfed), T_2= W_2 (IW: CPE=0.2), T_3= W_3 (IW: CPE=0.3), T_4= W_4 (IW: CPE=0.4). Field experiments were carriedout in Split Plot Design (SPD), with land management practices as main plots and water management as the sub plots treatments.

Cropping history of experimental site

It is worth to mention here that this was Ninth lentil crop in the planned crop rortaion where lentil occupies during cool season in same experimental plot. Prior to this experiment four cycles of lentil were already harvested till 2016 (Table 1).

Table 1: Cropping History of experimental site

Years	Cropping System	Remarks
2010-11	Rice – Lentil	General Crop
2011-12	Rice – Lentil	
2012-13	Rice – Lentil	
2013 - 14	Rice – Lentil	Experiment crop
2014-15	Rice – Lentil	
2015-16	Rice – Lentil	
2016-17	Rice – Lentil – Moonbeam	Present experiment
2017-18	Rice – Lentil – Moonbeam	
2018-19	Rice – Lentil – Moonbeam	

During present experiment as well as earlier trials in the same plot, sporadic root rot incidences have occured in patches (Fig. 1 and Fig. 2 However during third cropping cycle (Fig. 1), clearly indicates heavy infestation of root rot complex.

Fig. 1 Field view of lentil crop under field condition during 2018-19

Crop and cultivar

Lentil(Lens culinaris) cultivar HUL 57 was grown as per the technical program under zero tillage and conventional tillage system.

Field view of lentil crop under field condition during the Year 2016-17

Field view of lentil crop under field condition during the Year 2017-18

Fig. 2: Field view of lentil crop under field condition during normal seasons

Pathological observations

Experimental plots were inspected regularly to record the percentage disease incidence (PDI) of lentil was recorded at every alternate day from seedling to maturity of the crop in both Conventional tillage (CT) and conservation tillage (ZT) treatments. The root rot incidence from each plot was recorded twice (i.e. at 30 and 60 Days after sowing). The percent disease incidence (PDI) was calculated by using the following formula:

$$PDI = \frac{\text{Total number of plants infected}}{\text{Total number of plants observed}} *100$$

Isolation of pathogen

Diseased plants were collected for identification and isolation of pathogens. A total of ten plants showing mortality symptoms were randomly selected and roots of these plants were collected. associated pathogen was isolated from each of the collected sample after surface sterilization with 1% Mercuric chloride solution followed by three washing with sterile distilled water. Excess water was removed using sterile blotting papers. Isolated sections were inoculated on PDA medium and incubated at 28°±0.5°C in BOD incubators. The isolated fungi were observed for The fungal isolates were identified on the basis of its colony characteristics and spore morphology using compound microscope.

Statistical Analysis

All the data were recorded were subjected to to statistical analysis. Seed yield was recorded on individual plot basis and converted in to kg/ha. Analyses of variance was performed for each trait for all three seasons and the combined (Pooled) analysis over seasons after testing error variance homogeneity was carried out according to the procedure outlined by Gomez and Gomez (1984), using the MSTATC version 2.1 (Michigan State University, USA) statistical package design. Significant differences between the treatments were compared with the critical difference at (± 5%) probability by LSD.

RESULTS AND DISCUSSION

This experiment was conducted under cropping system mode which includes rice-lentil-mungbean. However, here we are focusing specifically only on the influence land and water management practices on the dynamic of lentil root rot complex. Lentil being second crop in sequence, was occupied filed during rabi season. Results obtained based on observation taken and data recorded, were discussed here under suitable subhead.

Morphological and cultural characters as Rhizoctonia spp. and Fusarium spp.

Cultural characters of Rhizoctonia:

The hyphae of R. solani was like a long tube and septa or partition inside. The branches of hyphae were tapered and perpendicular angles (Fig. 3A) . At the point of the branch,

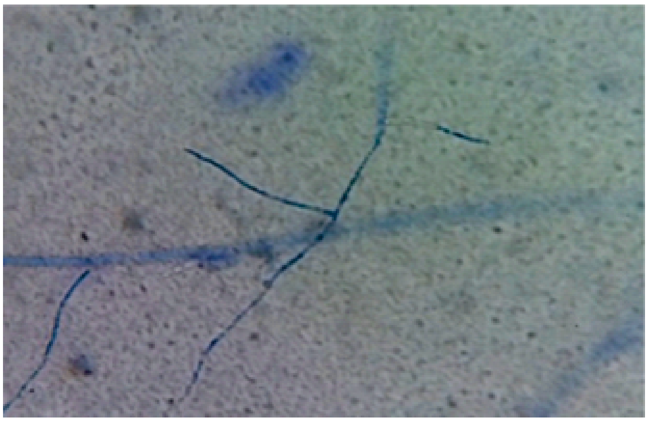

Fig. 3a: Hyphae of Rhizoctonia

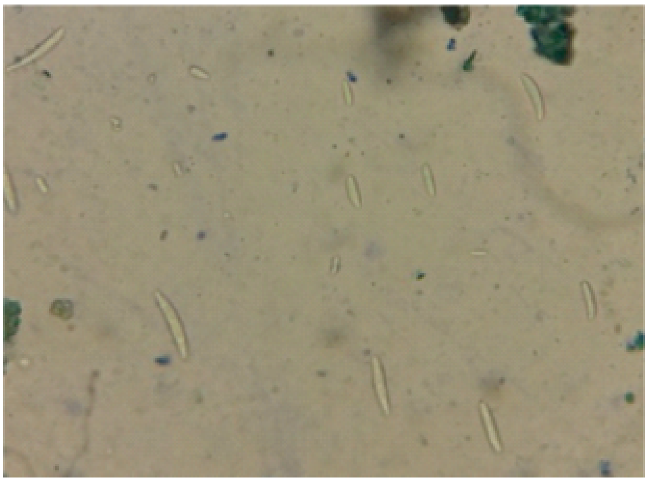

Fig. 3b: Spores of Fusarium

Fig. 3: Fungus isolated from rhizospheric region of infected lentil plants of experimental field

there was a curve / slightly narrowed, and there was a septum. The young hyphae R. solani had branches forming 90° angles, the more mature branches will be perpendicular and same size. Adult hyphae become stiff because of the thickened cell walls. Test of morphological characteristics of isolates with three replications. The mycelial growth was rapid in the isolates. The growth was rapid on the third day of mycelia has grown reach on Petri dish diameter (90 μm), slow if on the third day less than 90 μm. Colony color were white and cream color. The color of a young colony tends to be white, the older isolate turns to brown. The size of sclerotia is classified into macro sclerotia and micro sclerotia. Mostly macro sclerotia are blackish brown, look at a small round with size 1 μm. Micro sclerotia are shaped like a thin crust on PDA media originally white and small. The size of appeared sclerotia was inconsistent on three replicates origin of one isolate. The sclerotia color were diverse in white, pale brown and dark brown. The distribution pattern of sclerotia was diverse as large concentric ringsrare concentric rings and concentrated at the edges and lots.

Cultural characters of Fusarium:

The Fusarium sp. was characterized by extensive mycelial growth and cotton like texture, septate and hyaline hyphae, both macro and micro conidia were observed, conidia were two or more celled, smooth, sickle shaped (Fig. 3b). Conidiophores were attached with long chain of macroconidia and few with microconidia. Macroconidia were 2-5 celled and measured 18.8-86.5 x 2.5-5.2 μm.)

Time taken to buildup root rot complex toeconomic threshold injury level (ETL)

Before discussing results, it is but obvious to discuss the time taken to buildup root rot pathogen to the Economic threshold injury level (ETL). It is worth to mention here that this piece of land was brought under cultivation after two decade of remain ideal and without cultivation as barren and abounded land. Cultivation and crop husbandry was resumed since 2010-11 with rice –lentil cropping system as general crop. Since then this was 9th season of lentil on same plot under intensive cropping system, when root rot complex was attached severely (Table 1). Sporadic and once in a while unnoticed root rot incidence cannot be ruled out.

Effect of land and water management on root rot incidence

Data pertaining to root rot disease infestation was collected twice at 30 days interval on 30 DAS and 60 DAS and presented in Table 2. It was noticed that zero tilled plot was significantly less infected by root rot complex as compared to the conventional tilled plot. This might be due to the restricted movement of both the pathogens i.e. Rhizoctonia and Fusarium due to more soil compaction under zero tilled plot as compared to the conventional plot. Similar trend was also maintained till the end of cropping season. Water management treatments indicated that Rhizoctonia solani multiplied very fast under favourable moisture regime, whereas under normal or dry condition Fusarium can flourished better than Rhizoctonia solani (Mamta and Pande, 2013).

Table 2: Effect of land and water management on root rot incidence (%) in lentil

Treatments	Root rot incidence (%)	
	30DAS	60DAS
Zero Tillage	7.5	69.6
Conventional Tillage	13.3	83.3
CD (P=0.05)	3.1	11.7
W_1 (Rainfed)	10.2	68.3
W_2 (IW:CPE=0.2)	10.6	70.6
W_3 (IW:CPE=0.3)	11.8	66.3
W_4 (IW:CPE=0.4)	13.7	70.6
CD (P=0.05)	4.3	12.4

Interaction effect of land and water management on root rot

Perusal of data presented in Table 3 clearly indicate that, there was close association among the treatments imposed on lentil with respect to the invasion of root rot complex. Zero tilled plot has got less buildup of pathogens. Hence, significantly less incidence was reported among water management treatments except water managed at IW:CPE=0.4 under treatment W_4 at 30 DAS, whereas it was uniform and gradually progressed up to highest water management option when it was recorded at 60 DAS. Results indicate that at 30 DAS, buildup of disease causing pathogens i.e. Rhizoctonia and Fusarium was comparatively less as compared to 60 DAS (Table 3). Positive interaction among the treatment on root rot complex buildup might be due to the nature of both the fungus as reported by Singh et al., 2018.

Table 3: Interaction effect of land and water management on of root rot incidence (%) in Lentil

Treatments	30 DAS			
	W_1 (Rainfed)	W_2 (IW:CPE =0.2)	W_3 (IW:CPE =0.3)	W_4 (IW:CPE =0.4)
Zero Tillage	9.0	7.1	7.8	6.1
Conventional Tillage	11.4	14.2	15.8	11.6
CD (P=0.05)	1.1	1.7	1.5	2.1
	60 DAS			
Zero Tillage	52.5	55.7	51.4	58.8
Conventional Tillage	84.1	81.2	81.2	82.4
CD (P=0.05)	4.8	5.3	5.5	5.7

Table 4: Lentil performance under normal year and sever root rotconditionin flueanced by land and water management

Treatments	Pooled(2016 - 17 & 2017-18)		2018-19	
	Grain yield (t/ha)	HI (%)	Grain yield (t/ha)	HI (%)
Zero Tillage	1130	27.37	71.8	4.6
Conventional Tillage	1059	24.83	57.3	5.7
CD (P=0.05)	61	2.33	5.6	NS
W_1 (Rainfed)	950	22.57	79.1	6.3
W_2 (IW:CPE=0.2)	1061	24.95	48.5	4.0
W_3 (IW:CPE=0.3)	1310	30.56	53.7	4.4
W_4 (IW:CPE=0.4)	1050	26.32	76.8	5.9
CD (P=0.05)	21	5.18	6.2	1.1

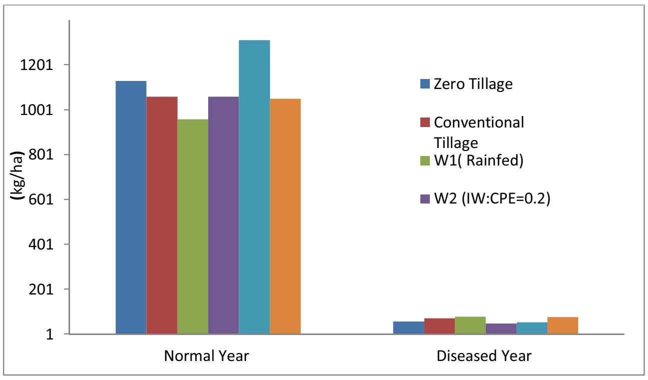

Fig. 4 : Lentil performance under normal and diseased year

Lentil performance during normal year v/s diseased year

To assess the impact of root rot complex on performance of lentil, data for normal crop i.e. 2016-17 were pooled and compared with diseased years i.e. 2017-18 and presented in Table 4. Perusal of results revealed that not only severe reduction in grain yield but also in case harvest index was also noticed. During normal year lentil seed yield ranged beeween 950 kg to 1310 kg, corresponding seed yield was drastically low to the tumne of 48.5 to 79.1 kg/ha. Likewise harvest index (HI) was also decreaded under diseased years from >22% to <6.5%. In case of lentil, zero tilled plot produced significantly higher seed yield (1130kgt/ha) as compared to conventional tillage (1059kg/ha). In case of water management highest seed yield 1310 kg/ha) was recorded with W_3 water management treatment, corresponding minimum was reported (950kg/ha) with two irrigations at IW: CPE = 0.6 (W_1) during normal year (Fig. 4 and Table 4).

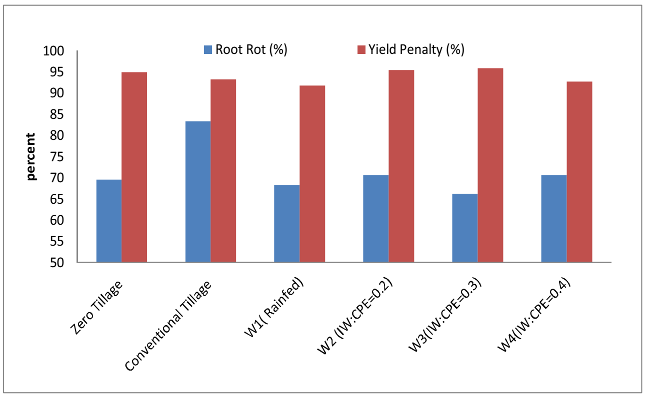

Fig. 5 : Yield penalty due incidence of root rot complex

Recommendation

Both the root rot causing pathogens can survives very well on plant debris and in soil comfortably, which can be aggravated if there is lack of availability of resistant varieties. Due to its complex nature managing water is very tricky. Crop rotation, use of resistant cultivar along with prophylactic seed treatment is the best way cope up this disease only way to manage root rot complex.

CONCLUSION

This investigation once again established the cause and effects relationship amongst host-plant and environment in close vicinity and interactive association. Buildup of root rot complex diseases can be more easer in conventional tilled plot as compare to zero tilled plot. Water management option not influence much as *Rhizoctonia spp*. and *Fusarium spp*. are divers in nature and their preference toward moisture level are mutually benefitted for the buildup of root rot complex. It was worked out that if the disease severity index crossed 65 % mark their would ne greater chances for maximum yield penalty, that can be > 80 %. Lentils are more susceptible to root rot disease complex at reproductived stage than initial and primary grorth stages. It was also concluded that under Bihar condition, average time taken to root rot build to economic threshold level, in new field taken under cultivation may takes 9 nine crop cyclce.

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