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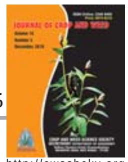

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Study of disease complex in *rabi* oilseeds grown in *kharif* rice (*Oryza sativa* L.) – lands under agro-climatic condition of Central Brahmaputra Valley Zone of Assam

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ABSTRACT

A field experiment was conducted at Shillongani during rabi seasons of 2016-17 and 2017-18 in loamy soils of Central Brahmaputra Valley Zone (CBVZ) of Assam to study the diseases of rapeseed (Brassica campestris) and linseed (Linumusitassimum), their severity, yield loss and population of soil microorganism (fungi, actinomycetes and bacteria) under rice (Oryza sativa)-fallow and conventional system as well as under protected and unprotected conditions. In rapeseed, Alternaria leafblight (ALB) caused by A. spp.and collar rot caused by Sclerotiumrolfsii were the major diseases. The severity ofALB at 60 days after sowing (DAS) was higher under conventional system (26.60 and 29.23 % in 2016-17 and 2017-18, respectively) than in rice-land (24.17 and 24.06% in respective years). In conventional system, its severity was 17.23 % in 2016-17 and 19.67 % in 2017-18 under protected condition and 35.97 and 38.78 % in respective years under unprotected conditions. However, in rice-fallows, it was 15.97 and 16.23 % under protected and 32.37 and 31.89 % under unprotected conditions. Collar rot of rapeseed was observed only in the first year of study. The per cent severity was higher in rice-lands (0.92) than in conventional system (0.43). The yield loss ranged from 9.6-12.2 % under rice-fallow. In linseed, Fusarium wilt caused by F.oxysporum was the major disease. The severity of Fusarium wilt was slightly higher under conventional system (1.62 and 2.63 % in respective years) than in rice-lands (1.40 % and 2.18 %). Its severity was 0.31 and 1.01 % in rice-fallows under protected conditions and 2.49 and3.34 % under unprotected conditions in the years of experimentation, respectively. However, under conventional system, it was 0.53 and 1.27 % in protected and 2.70 and 3.98 % in unprotected conditions in the respective years. The seed yield of linseed in rice-lands (9.34 and 8.92 q ha^{-1}) was higher than those in conventional system during both the years. Soil moisture was higher in rice-lands than in conventional system irrespective of crop grown during the growing period. Rice-lands registered higher population of bacteria and lower fungi and actinomycetes in soil at 90 DAS as compared to those under conventional.

Keywords **:** Disease complex, linseed, microbial population, rapeseed, rice-fallow, yield loss

The Indian economy is largely agrarian, with around 55 per cent of the population dependent for their livelihoods on agriculture and allied sectors (GOI, 2017). The green revolution that had affected the major lift in crop yield during 1960s and 1970s is now showing signs of slow growth in productivity gains. Intensive agriculture practised without maintaining ecological balance has led to degradation of soil health and decline in availability of fresh water resources (Kesavan and Swaminathan, 2008). The negative impacts of climate changes have been seen to disrupt the balance between food supply and demand by shifting abruptly from its surplus to deficit. The ever increasing population has aggravated the situation. Assam has achieved near self sufficiency in rice production, however, it continues to be deficit in oilseeds and pulses. In oilseed production, the state is experiencing about 65 per cent deficit as related to its requirement. The productivity of total oilseeds remains almost stagnant for the last decade or so. Therefore, horizontal approach by crop intensification appears to be most viable option for increasing oilseeds production utilizing the rice-fallows. Deka *et. al.* (2013) suggested that crop intensification through multiple cropping in rice-lands is of prime importance. In Assam, there remains about 6.5 lakh ha of medium structured medium winter rice-lands fallow every year. In such lands, *rabi* oilseeds like rapeseed, linseed and niger (*Guizotiaabyssinica*) come up very well (Deka *et al*., 2018 and Deka *et al.*, 2019). In West Bengal, farmers prefer to shift from relay cropping of grasspea (*Lathyrus sativa*) with winter rice to more remunerative crops like rapeseed, mustard, *etc*. In rice-fallows, even if the *rabi* pulses are sown timely, they often experience high incidence of insect-pests and diseases. Although detailed study on dynamics of diseases have not been well taken up, yet these biotic agents thrive well under such a situation to cause perceptible damages afterwards (Singh *et al*., 2017). However, this statement might be unlikely in toto because of the fact that due to prevailing anaerobic conditions in rice cultivation, many of the micro organisms cannot thrive well under such a situation. Likewise, in *rabi* oilseeds, dynamics of diseases has also not been comprehensively addressed to in rice-fallows. Therefore, the present investigation was designed in rapeseed and linseed with the following objectives.

i) To study the severity of major diseases of rapeseed and linseed grown after rice (rice fallow agro-ecosystem) in comparison to that grown after *kharif* mungbean (*Vignaradiata*) under protected (disease management practices adopted) and unprotected conditions.

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ii) To study the soil microbial population dynamics and soil moisture depletion pattern in rice-lands during *rabi* crop growth period *vis-à-vis* conventional agro-ecosystem and

iii) To find out yield loss on account of agro-ecosystem variability and varying disease severity.

MATERIALS AND METHODS

A field experiment was conducted during winter (*Rabi*) seasons of 2016-17 and 2017-18 at Regional Agricultural Research Station, Assam Agricultural University,Shillongani, Nagaon, Assam (92¹65° E longitude, 26.21° N latitude and 50.2 m above MSL). The two agro-ecosystems (rice-fallow and conventional) were places in main plots and the combination of crops (rapeseed and linseed) and disease management levels (protected and unprotected) in sub-plots of a split-plot design with four replications. In the first agro-ecosystem, rapeseed (variety 'TS 67') and linseed (variety 'T 397') were sown after harvest of *kharif* rice on conventionally tilled (2 harrowings + 1 roto-tilling) soils. However, in the second agro-ecosystem, crops were grown after *kharif* mungbean with conventional tillage. In both the system, crops were sown duringthe fourth week of November. The disease management level 'protected' involved adoption of all recommended practices wherever necessary, whereas, there was no any disease management practice adopted in case of 'unprotected'. Under protected condition, control measures adopted comprised seed treatment with metalaxyl @6 g kg^{-1} of seed for *toria* and soil drenching with carbendazim 50 WP @ 2ml/l in linseed. The soil was loamy having pH 5.6, organic C 0.80%, available N 278.4 kg ha^{-1}, available P_2O_5 22.0 kg ha^{-1} and available K_2O 137.3 kg ha^{-1}. The field capacity of the soil was 24.4%. The mean maximum and minimum temperature experienced were in the range of 21.5° to 28.2°C and 10.6° to 15.6°C, respectively ; relative humidity ranged from 82.4 to 93.6 per cent (morning) and 57.3 to 74.0 per cent (evening) during the crop season, while rainfall was 83.6 mm in 2016-17 and 32.8 mm in 2017-18. The periodical soil moisture was recorded using soil moisture meter.

Five composite soil samples (0-10 cm depth) representing the area were collected randomly. Each composite soil sample was air dried, processed with the help of pestle and mortar, passed through 2 mm sieve and used for the analysis of biological properties. For estimation of soil microorganisms, serial dilution plating method was used as described by Pramer and Schmidt (1966). The isolation of bacteria, fungi and actinomycetes from soil samples was done by taking 10 g freshly collected ground soil in 250 ml Erlenmeyer flasks containing 100 ml distilled water and shaken for 15 min on a horizontal mechanical shaker. Fungal population was estimated by using Potato Dextrose Agar, bacterial population by Nutrient Agar and actinomycetes by using Starch Casein Agar medium (Williams and Davis, 1965). The suspension was further diluted to 10^{-5} using sterile distilled water. One ml of aliquot of 10^{-5} dilution for fungi, bacteria and actinomycetes was inoculated in petridishes. Approximately fifteen ml of molten and cooled (40°C) PDA, NA and SCA media was poured separately into each petridish for isolation of fungi, bacteria and actinomycetes, respectively. The dishes were then incubated at 25±2° C. Total number of colonies that developed on respective media was counted by placing the plate on the platform of a Quebec colony counter. Counts of the colonies were expressed as the number of colony forming units (CFU) per gram dry weight of the sample.

$$\text{Organisms per mm per gram of sample} = \frac{\text{No. of colonies (av. of 3 replications)}}{\text{Amount plated x Dilution}}$$

The data were analysed statistically by using factorial RBD. The data collected on different soil properties were analysed applying ANOVA technique (Panse and Sukhatme, 1961).

The disease severity was recorded at 60 DAS on leaves when there was maximum disease pressure. A 0-9 scale (Conn *et al.*,1990) was used for rating of treatments. The scale was as follows:

Scale	Description
0	No lesion
1 (HR)	Non-sporulating pinpoint size or small brown necrotic spots, < 5% leaf area covered by lesion
3 (R)	Small roundish slightly larger brown necrotic spots, about 1-2 mm in diameter with a distinct margin or yellow halo, 5-10% leaf area covered by lesion
5 (MR)	Moderately sporulating, non-coalescing, larger brown spots, about 2-4 mm in diameter with a distinct margin or yellow halo, 11-25% leaf area covered by the spots
7 (S)	Moderately sporulating, coalescing larger brown spots about 4-5 mm in diameter, 26-50% leaf area covered by the lesions
9 (HS)	Profusely sporulating, rapidly coalescing brown to black spots measuring more than 6 mm diameter without magins covering more than 50% leaf area

Table 1: Per cent disease severity and seed yield of toria

Treatments	2016-17				2017-18		
	Collar rot incidence (%)	ALB at 60 DAS (%)	Yield (q ha^{-1})	Yield loss (%)	ALB at 60 DAS (%)	Yield (q ha^{-1})	Yield loss (%)
				Rice-fallow			
Protected	0.48	15.97	9.67	-	16.23	9.33	-
Unprotected	1.35	32.37	8.33	13.9	31.89	8.00	14.2
Mean	0.92	24.17	9.00		24.06	8.67	
				Conventional			
Protected	0.15	17.23	11.00	-	19.67	10.50	-
Unprotected	0.71	35.97	9.50	13.6	38.78	8.67	17.4
Mean	0.43	26.60	10.25		29.23	9.59	

Table 2: Per cent disease incidence and seed yield of linseed

Treatments	2016-17			2017-18		
	Fusarium wilt incidence (%)	Yield (q ha^{-1})	Yield loss (%)	Fusarium wilt incidence (%)	Yield (q ha^{-1})	Yield loss (%)
			Rice-fallow			
Protected	0.31	10.0	-	1.01	9.83	-
Unprotected	2.49	8.67	13.3	3.34	8.00	18.6
Mean	1.40	9.34		2.18	8.92	
			Conventional			
Protected	0.53	9.67	-	1.27	9.33	-
Unprotected	2.70	8.00	17.3	3.98	7.50	19.6
Mean	1.62	8.84		2.63	8.42	

Table 3: Soil microbial population under different agro-ecosystems

Treatments	Fungi (x10^5 cfu g^{-1} of soil)			Actinomycetes (x10^5 cfu g^{-1} of soil)			Bacteria (x10^5 cfu g^{-1} of soil)		
	Initial	2016-17	2017-18	Initial	2016-17	2017-18	Initial	2016-17	2017-18
					Ecosystem				
Rice-fallow	1.23	11.78	16.13	13.67	16.92	19.95	59.67	56.00	61.65
Conventional	31.61	32.83	34.10	19.21	18.42	20.83	48.61	49.92	46.33
LSD (0.05)		3.10	2.37		5.64	5.70		NS	NS

Table 4: Per cent yield loss in Toria and Linseed under different agro-ecosystems

Treatments	Toria		Linseed	
	2016-17	2017-18	2016-17	2017-18
Protected Rice-fallow	12.7	11.1	-	-
Protected Conventional	-	-	3.0	5.0
Unprotected Rice-fallow	24.3	23.8	13.3	18.6
Unprotected Conventional	13.6	17.4	20.0	23.7

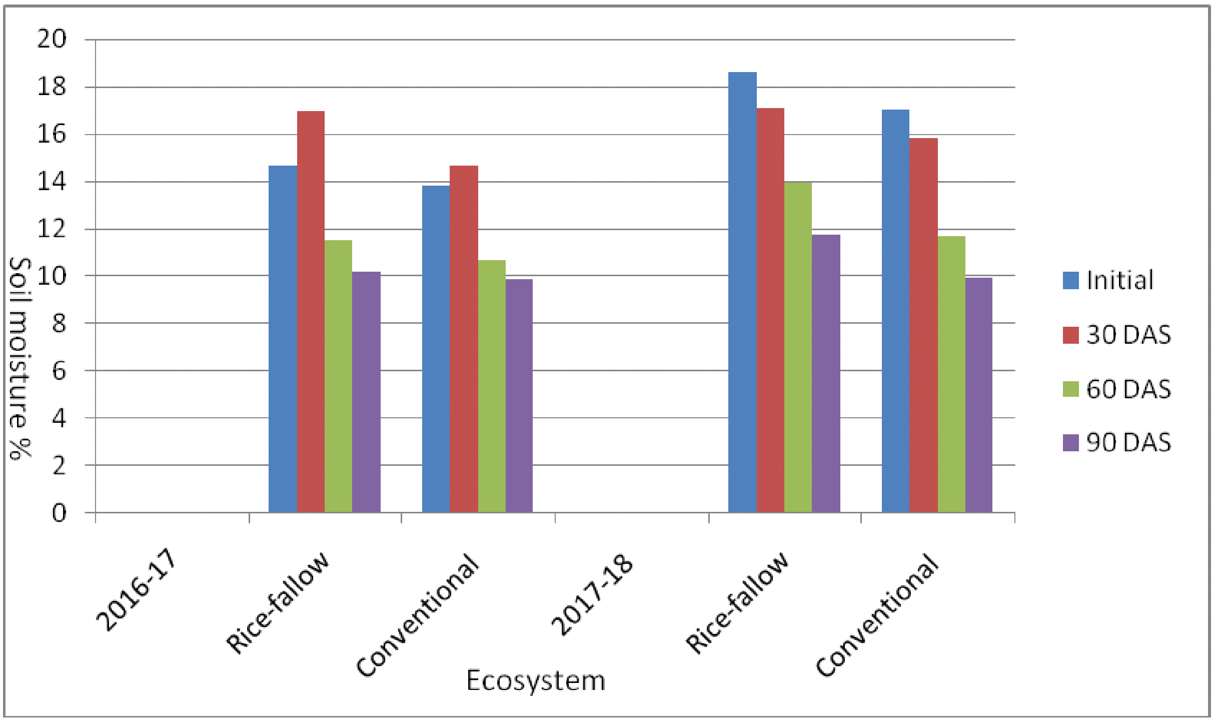

Fig. 1: Periodical soil moisture percent

$$\text{Average severity score} = \frac{(N-1\,x\,0)+(N-2\,x\,1)+(N-3\,x\,3)+(N-4\,x\,5)+(N-5\,x\,7)+(N-6\,x\,9)}{\text{Number of leaf samples}}$$

$$\text{Per cent Disease Intensity (PDI)} = \frac{(N-1\text{ x }0)+(N-2\text{ x }1)+(N-3\text{ x }3)+(N-4\text{ x }5)+(N-5\text{ x }7)+(N-6\text{ x }9)\text{ x }100}{\text{No. of leaf samples x }9}$$

Where N-1 to N-6 represents frequency of leaves in the respective score.

The Fusarium wilt incidence was calculated by deducting the number of plants survived from the initial plant stand and converted into percentage using the formula given as below :

$$\text{Per cent wilt incidence} = \frac{\text{No. of wilted plant x100}}{\text{Total no. of plant}}$$

RESULTS AND DISCUSSION

Disease severity in rapeseed

Alternaria leaf blight was the major disease under both the agro-ecosystems (Table 1). The severity of ALB at 60 DAS was higher under conventional system (26.60 and 29.23 % in 2016-17 and 2017-18, respectively) than in rice-lands (24.17 and 24.06% in respective years). In conventional system, its severity was 17.23 in the first year and 19.67 per cent in the second year under protected condition, and 35.97 and 38.78 per cent under unprotected control. However, in rapeseed grown in rice-lands, it was 15.97 and 16.23 per cent under protected and 32.37 and 31.89 per cent under unprotected conditions. Das *et al.* (2018) stated that ALB was the major disease of rapeseed-mustard under rice-fallow conditions. Collar rot appeared to be a minor disease as it was observed only during the first year of experimentation with very low severity ranging from 0.15 to 1.35 per cent. Of course, its severity was higher in rice-lands (0.92 %) than in conventional system (0.43 %). Gupta *et al.* (2016) noted that collar rot caused by *S.rolfsii* was the most common soil borne disease of rice-fallow pulses.

Disease severity in linseed

Fusarium wilt was the only disease observed in linseed under conventional and rice-fallow systems. It is a soil borne disease which appears in urdbean (*Vignamungo*) only under rice fallows (Gupta *et al.*, 2016). Its incidence in linseed was marginally higher under conventional system (1.62 and 2.63 % in respective years) as against in rice-lands (1.40 and 2.18 %) (Table 2). Under conventional system, it was 0.53 and 1.27 per cent in protected and 2.70 and 3.98 per cent in unprotected conditions respectively during the two years of study. However, it was 0.31 and 1.01 per cent in rice-lands under protected condition, and 2.49 and 3.34 per cent under unprotected condition. Kumar *et al*. (2017) narrated that consequent upon continuous cropping of linseed in same marginalized field, year after year, soil becomes sick with *Fusarium* spp. besides some other pathogens resulting in partial or total yield loss.

Periodical soil moisture and microbial population

The initial soil moisture in both the ecosystems was almost equal.However, periodical soil moisture depletion pattern (Fig. 1) revealed that rice-lands accounted for better soil moisture conservation throughout the crop growing period during both the years of study as compared to the conventional system irrespective of crops grown. This might be attributed to rice stubbles that restricted the evaporation loss of residual soil moisture.

Population of soil microorganisms were studied and presented in table 3 categorized under the two agro-ecosystems. The initial fungi population was considerably lower in soil after rice harvest as against that in soil under conventional system. The prevailing anaerobic condition caused by stagnant waterduring greater part of rice growing period led to lower fungal population in rice fallow (Singh *et al*., 2017). Similarly, at 90 DAS of *rabi* crops, fungal population was considerably lower in rice-land ecosystem than in conventional system. Actinomycetes population was marginally lesser in rice-lands before sowing of the *rabi* crops and the same trend was observed at 90 DAS in comparison to conventional system during both the years of experimentation. In constrast, population of bacteria was considerably higher in rice-lands at sowing as well as at 90 DAS of the *rabi* oilseeds as compared to conventional system. The higher bacterial population in soil of rice-lands after rice harvest and during the growing period of *rabi* crops might be attributed to survivability of bacteria under anaerobic condition, better soil moisture conservation and higher organic matter.

Seed yield and yield loss

Rapeseed gave higher seed yield under conventional system (10.25 q ha^{-1}) than in rice-lands (9.00 q ha^{-1}) (Table 1). This might be owing to better crop establishment and root penetration in finely tilled soil under conventional system. Whereas, linseed produced higherseed yield while grown on rice-lands (9.34 q ha^{-1}) than that under conventional system (8.84 q ha^{-1}) (Table 2). This showed relatively better adaptation of linseed in rice-fallow agro-ecosystem. Kumar *et al*.(2019) also elicited that linseed performed well in rice-fallows. Obviously both the crops in both the agro-ecosystems yielded higher under protected condition owing to better management of diseases. The yield loss in rapeseed dueto disease pressure ranged from 13.6-13.9 per cent in 2016-17 and from 14.2-17.4 per cent in 2017-18. However, the unaddressed diseases caused much more yield loss under conventional agro-ecosystem due to considerably higher disease severity, especially that of ALB as against in rice-fallow agro-ecosystem. Rapeseed yield was the maximum (11.00 q ha^{-1} in 2016-17 and 10.50 q ha^{-1} in 2017-18) under protected conventional system. As compared to this system, yield loss under protected rice-fallow ranged from 11.1-12.7 per cent, under unprotected rice-fallow 23.8-24.3 per cent and under unprotected conventional system ranged from 13.6-17.4 per cent in rapeseed (Table 4). Unmanaged *Fusarium* wilt in linseed led to yield loss of 13.3-17.3 per cent in the first year, whereas, from 18.6-19.6 per cent in the second year (Table 2). Under conventional system such yield loss was much prominent than in rice-fallow agro-ecosystem. This might be attributed to higher wilt severity in conventional system. Linseed yielded the highest (10.00 q ha^{-1} in 2016-17 and 9.83 q ha^{-1} in 2017-18) in protected rice-fallow agro-ecosystem. In comparison to this system, 3-5 per cent yield loss under protected conventional, 13.3-18.6 per cent under unprotected rice-fallow and 20.0-23.7 per cent under unprotected conventional agro-ecosystem were experienced (Table 4).

Way forward

Rice-fallows offer a great opportunity to maximize area under oilseeds and pulses with adoption of appropriate agro-techniques. Mitigation of abiotic and biotic stresses is a major concern in successful trapping of rice-fallows. For better utilization, intensive research is needed to understand the rice-fallow ecology for strategic crop management. Rice-fallow ecology varies from region to region and from one soil type to another and it also experiences varying disease complexes and disease severity. On this aspect, research is almost lacking in Assam, therefore, intensive research is the need of the hour for converting rice-fallows into productive lands by growing suitable oilseeds/pulses with proper disease management approaches.

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