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Rapeseed yield loss estimates through selected biotic pressures

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Abstract
The field experiment was conducted during *Rabi* season of 2015 at Viswavidyalaya farm on rapeseed with variety Benoy (B9) to study the effects of three major pests (weed, insect and pathogen) on biological productivity Laid out in paired plots for weed, insect and diseases the six plots were replicated six times for analyzing under T test. Losses due to the identified invading weed, insect and pathogen pests contributed to respective percentages of 19.89, 32.10 and 11.71 in seed yield and 5.79, 2.97 and 4.03 for oil content. Eco-safe managements, within 30 DAS, avoided yield loss by weed while insects and pathogens were controlled beyond 40 DAS. These findings may help farmers to strategize their crop protection plan accordingly in rapeseed in the light of individuals' resource affordability.

Keywords: Rapeseed, dominant pest complex, yield loss

Introduction
The oilseed sector has been an important area of concern and policy makers in the post-reforms period when India became one of the largest importers of edible oils in the world, importing about half of domestic requirement in the 1990s. In India, oilseeds contribute 3% and 10% to gross national products and value of all agricultural products, respectively, with 14 and 1 million people involved in oilseed cultivation and processing, respectively [1]. Most of the oilseeds are grown under rain-fed conditions, and only 25% of area under oilseeds is irrigated. Several biotic, abiotic, technological, institutional, and socio-economic constraints also inhibit exploitation of the yield potential of crops and need to be addressed. Rapeseed-mustard is also an important oilseed crop in the country occupying the second position after soybean. Though, rapeseed-mustard ranks second in terms of production, after soybean, however due to more oil content (ranging from 35- 45%) rapeseed-mustard ranks 1st in terms of oil yield among all oilseeds crops. Rapeseed-Mustard is cultivated over an area of about 61.3 lakh ha with a production of 71.3 lakh tonnes and productivity of about 1163 kg per ha during the TE 2011-12 [1]. The projection of per capita consumption of oil crops in 2050 for food and all uses is estimated to be 16 and 30 kg, respectively. In South Asia which includes India, the same is projected at 16.7 kg capita^{-1} annum^{-1} in 2050 [2]. Rapeseed-mustard yields, which were low (about 647 kg ha^{-1} on the average) during the early-1980s, witnessed a steady increase during the last three decades and reached a level of 1121 kg ha^{-1} in the recent decade in India. West Bengal (911 kg ha^{-1}), has the lowest yield. After an initial area expansion and concurrent rise in production, during the decade of nineties, area under oilseeds recorded a negative growth rate (-0.9%) while productivity improved marginally (1.4). Therefore, efforts are needed to improve rapeseed-mustard yield to increase production as there is a limited scope for increasing area under oilseeds.

High cost of inputs, shortage of labour, production and price risks were important economic constraints faced by oilseed growers in the study area. Incidence of insect pests and diseases, lack of suitable varieties, and irrigation facilities were the main technological constraints in rapeseed-mustard cultivation. Production has to be increased vertically taking in to account the exploitable yield reservoir. Other than crop production and crop improvement approaches, crop protection strategies are to be developed. The losses in oilseed crops due to biotic stresses are about 19.9% which affect the plant at different growth stages. Various plant pathogens, insects and weeds are reported to affect the crop.

Pest causes 33 % production losses of agriculture crops and the agent wise contribution are: weed 12.5, insect 9.5, pathogens 6.5 and other pests 4.5% [3]. Database regarding pest loss contribution in oilseeds including rapeseed is also lacking. In rapeseed and mustard, many of the weeds are specific to crop and/or location, *Chenopodium, Asphodelus, Melilotus* and *Trianthema* spp. cause serious yield losses in other areas [4]. Among the various diseases, *Alternaria* leaf blight is the most destructive diseases incited by *Alternaria brassicae, Alternaria raphani* and *Alternaria brassicicola* singly or by mixed infection. The pathogen is a necrotroph and causes lesions surrounded by chlorotic areas on leaves, stems and siliqua of the crop and causes considerable depletion of the quantity and quality in the harvested products [5] and therefore makes it a relevant issue. A number of insect pests are known to attack rapeseed-mustard right from sowing till harvest. Only a few of the insects cause serious losses. In a rough estimate, rapeseed-mustard in India generally suffers a 30 per cent yield loss due to insect pests. Insect pest loss emerging in oilseeds is estimated to 27,300 million of Indian rupees annually (approximately 600 million US dollars). For this reason, a need was felt to generate location specific information about the amount of damage that these pests inflict on different oilseed *Brassica*. For edible oil security these pest losses are needed to be assessed, for different agro climatic locations and minimized for *Brassica* [3]. Such information is also important to frame our research priorities involving pests, pathogens and weeds [6]. Considering these facts, an experiment has been carried out to estimate the yield losses of rapeseed due to the three major pests (weed, insect and pathogen).

Materials and Methods

The field experiment was conducted in humid sub-tropics of West Bengal at the Instructional Farm, Jaguli of Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia during *Rabi* season of 2015. The experimental site is situated at 22°56' N latitude, 88°32' E longitude and at an altitude of 9.75 m above the mean sea level. The rapeseed variety was Benoy (B9) sown with 20 cm row spacing and with the plots had 2m buffering between them with recommended fertilizer doses N: P_2O_5: K_2O @ 80:40:40 kg ha^{-1} and 10 t ha^{-1}neem cake (excepting in untreated insect control plot). Weed pest control in the control plots were done by hand pulling out germinated weed flora at each week interval. Insect pest control measure was adopted by applying two insecticides, Profex Super 44EC, contact in nature, which is a mixture of Profenofos 40% + Cypermethrin 4% EC was sprayed at 25, 40, 55 DAS @ 1mllt^{-1} of water to control a wide range of insects along with Flonicamid 50 WG @ 0.5 g lit^{-1} of water for controlling of mustard aphid, while for pathogens the mixed fungicide Combi plus (Carbendazim 12% +Mancozeb 63% WP) @ 1.5 g lit^{-1} of water was used when the symptoms appeared in the field at 30 and 55 DAS. The statistical analysis of the recorded data was done by t-Test: two-sample assuming equal variance which is also known as Fisher t-Test, and to assess the losses caused by pests of summer rice, as suggested by Leclerg (1971) [7]. The experiment was divided into three separate parts (weed, insect and disease pests), two treatments for each pest viz. untreated control (unprotected) and full treated (protected) were replicated six times following pair plot technique.

The densities of different species of grasses, sedges and broad leaf weeds were recorded periodically. The observation for mean insect population plant^{-1} and their damage was counted in the early morning hours (by 7:00 a.m.) on the observation. The severity of *Alternaria* leaf blight disease taken periodically followed the rating scale as suggested by Sangeetha and Siddaramaiah, (2007) [8].After scoring, percent disease index (PDI) were calculated for each of the diseases separatelyas suggested by McKinny (1923) [9]. Growth and yield attributes were recorded resorting standard methods. Loss in yield was calculated by comparing the yield obtained from protected and unprotected plots using the following formula (Leclerg, 1971) [7].

$$\text{Loss in yield (\%)} = \frac{\sum_{i=1}^{n}(x_i - y_i)}{\sum_{i=1}^{n} x_i} \times 100$$

Where,
x = Yield in protected plots,
y = Yield in unprotected

Results and Discussion

In unprotected plots, weed density data revealed that in the terminal stage grassy weeds percentage increase was 9.52 with the predominant presence of Echinocloa *colona*, in broadleaved weeds the percentage increase was maximum with *Gnaphalium luteoalbum* (9.52). Among the dicots, *Physalis minima* had the highest dry matter accumulation at 50 DAS with 13.78. The order of DM accumulation in dicots followed the pattern *Physalis minima*> *Gnaphalium leuteoalbum*>*Digera arvensis* > *Cleome viscosa.* The percentage increase in dry weight was most during 30-50DAS of the crop.

Among Aphid, Diamond Back Moth (DBM) and Leaf Webber and *Coccinelid* predators of insects the DBM, Webber and the *Coccinelid's* infestation were from 30 DAS phase to the terminal stage. Aphids were mostly prevalent at the 50 and 70 DAS stages with respective significant population of 28.33 and 60.67 m^{-2} respectively. Population of *Coccinelid* predator, which rose was from 7.50-8.16 m^{-2} at 50 and 70 DAS was unable to control aphid infestation in rapeseed resulting in a aphid build up of 60.67 m^{-2} in the unprotected plots. High RH from late November to January might have resulted a higher level of aphid incidence. These findings were in line with the findings of Kular and Kumar (2011) [10].

The PDI for *Alternaria* blight in the protected plot had a peak incidence level of 12.66% (80 DAS). The unprotected plots had significantly higher incidence of pathogen from flowering with 15.18% and it varied narrowly at 60 and 80 DAS stages. The effect of blight on rapeseed with implied PDI which was earlier reported by Talukdar and Das (2015) [11]. The PDI in the protected plots might have been lower also owing to the effect of fungicides sprayed in the same.

Significant differences were observed on major growth (Table 5) and yield attributes (Table 6) between the protected and unprotected plots in weed pest experimental part. 40 DAS weed studies saw the protected plots had a mean LAI of 3.16 which is significantly higher than the corresponding value of 2.98 in the unprotected plots and enjoying similar trend in 60 DAS. For the disease study plots the 60 DAS crop the mean LAI of the protected plots were 3.29 which was significantly higher than that of the unprotected plots (3.15). Rapeseed leaf area index being depleted by weed density and competition was also reported formerly by Valizadeh and Mirshekari (2011) [12]. The percent depletion of LAI in weed affected plots were 6.42 at, 14.14 and 6.57 at the 40, 60 and 80 DAS respectively.

Leaf chlorophyll content Chlorophyll content (Table 5) at 40 DAS varied from 46.20-44.90 at the 60 DAS level for the weed experiment and 46.40-44.50 in the insect experiment at the 60 DAS crop. In the disease portion of the crop, the chlorophyll level drops down significantly in the unprotected plots with 39.20% from 42.74% at the 40 DAS and 40.90% from 46.30% at the 60 DAS implies disease severity in leaves and lesser chlorophyll content [13].

The mean dry matter of the crop across the dates of observation was significant and superior to the unprotected. The percentage reduction in dry matter because of weeds in the unprotected plots was 26.48; depletion owing to insects was 8.42 % and that because of disease was 12.21 % at the terminal stage of crop growth. The protected plots of weeds had a mean of 17.29 number of siliquae per plant significantly over the unprotected plot (13.10%) and such reports are supported by Valizadeh and Mirshekari (2011) [12], Roshdy (2008) [14], and Hosseini (2015) [15]. The insect studied plots the unprotected mean number of siliquae per plant was 13.03, significantly lower than the protected plots (17.10), accounting for a depletion of 23.79 %. This resulted in depletion of 18.29% in seeds per siliqua for the weed portion, 19.81% for the insect portion and 20.91% for the disease portion This might be owing to unfilled siliqua in many cases Brozozowski (1998) [16]. Reduction in number of siliquae owing to disease attack similarly was also reported by Pratap *et al*. (2014) [17].

The mean seed yield in the protected crops (1.60 t ha^{-1}) was significantly higher than that of the unprotected plots (1.28 t ha^{-1}). Weed growth accounted for 32.10% loss in seed yield; crop loss in terms of oil content was maximum in case of insects (5.79%) followed by disease (4.03 %) and least by weed infestation 2.97% recorded loss. More competition from weed flora in the critical phase of crop –weed completion decreases the growth and yield attributes in the unprotected plots [6]. Crop losses in rapeseed due to incidence of weed pests are in conformity of the findings of Singh *et al.* (2013) [4], Hosseni (2015) [15] and Bazaya *et al.* (2004) [18], who reported that proper weed-management practices improved the growth parameters and yield by eliminating weed competition. The results were in accordance with the findings of Mondal *et al.* 2017 [6] while working with yield loss due to pest's attack in SRI.

Table 1: Weed density and their increasing rate in unprotected plots of weed pest studies on Rapeseed

Weeds	**Number of weeds m^{-2}**			**Increasing rate (%)**	
	30 DAS	**50 DAS**	**70 DAS**	**30-50 DAS**	**50-70 DAS**
Grassy weeds					
Echinochloa colona	5.50 (2.45)	7.00 (2.74)	7.67 (2.68)	27.27	9.52
Digiteria sanguinalis	6.00 (2.55)	8.17 (2.95)	8.67 (3.03)	36.11	6.12
Other monocots	7.00 (2.74)	10.50 (3.32)	12.00 (3.54)	50.00	14.29
Sedge weeds					
Cyperus rotundus	17.33 (4.22)	22.33 (4.78)	28.00 (4.74)	28.85	25.37
Broadleaf weeds					
Cleome viscosa	4.83 (2.31)	8.33 (2.97)	8.83 (3.05)	72.41	6.00
Digera arvensis	5.83 (2.52)	9.17 (3.11)	9.50 (3.16)	57.14	3.64
Gnaphalium luteoalbum	7.67 (2.86)	10.50 (3.32)	11.50 (3.46)	36.96	9.52
Physalis minima	8.50 (3.00)	10.33 (3.29)	10.83 (3.37)	21.57	4.84
Other dicots	11.67 (3.49)	14.50 (3.87)	15.50 (4.00)	24.29	6.90

*Data in parenthesis are square root transformed value $\sqrt{(X+0.5)}$

Table 2: Weed biomass and their increasing rate in unprotected plots of weed pest studies on Rapeseed

Weeds	**Weed biomass (g m^{-2})**			**Increasing rate (%)**	
	30 DAS	**50 DAS**	**70 DAS**	**30-50 DAS**	**50-70 DAS**
Grassy weeds					
Echinochloa colona	3.79 (2.44) *	7.95 (2.92)	14.86 (3.92)	110.00	86.98
Digiteria sanguinalis	4.05 (2.13)	8.51 (3.00)	15.92 (4.05)	110.03	87.00
Other monocots	5.23 (2.39)	10.99 (3.39)	20.55 (4.59)	110.03	86.99
Sedge weeds					
Cyperus rotundus	8.54 (3.01)	14.85 (3.92)	21.20 (4.66)	73.99	42.72
Broadleaf weeds					
Cleome viscosa	2.87 (1.84)	6.60 (2.66)	7.48 (2.81)	130.04	13.36
Digera arvensis	3.80 (2.07)	8.74 (3.03)	12.47 (3.59)	130.01	42.77
Gnaphalium luteoalbum	4.97 (2.34)	11.44 (3.46)	21.75 (4.72)	130.03	90.14
Physalis minima	5.99 (2.54)	13.78 (3.78)	21.27 (4.67)	129.99	54.37
Other dicots	7.22 (2.78)	16.60 (4.14)	19.12 (4.44)	130.01	15.23

*Data in parenthesis are square root transformed value $\sqrt{(X+0.5)}$

Table 3: Insect incidences and their damage in insect pest studies of Rapeseed crop

Insect population m^{-2} and damage	Treatments	30 DAS	50 DAS	70 DAS
Aphid (Per 10 cm apical portion)	Protected	-	22.67 (4.85)	28.33 (5.38)
	Unprotected	-	32.50 (5.78)	60.67 (7.85)
	Fisher (*t*)	-	5.71**	7.97**
Diamond back moth	Protected	0.83 (1.33)	7.67 (2.89)	3.67 (2.12)
	Unprotected	2.50 (1.85)	13.17 (3.76)	6.33 (2.69)
	Fisher (*t*)	3.16*	2.33*	2.56*
Leaf webber	Protected	1.33 (1.49)	6.17 (2.65)	1.83 (1.63)
	Unprotected	3.16 (2.02)	12.17 (3.62)	4.33 (2.28)
	Fisher (*t*)	2.88*	6.03**	2.41*
Coccinellid predator	Protected	3.16 (2.02)	3.33 (2.06)	5.33 (2.49)
	Unprotected	6.66 (2.75)	7.50 (2.91)	8.16 (2.99)
	Fisher (*t*)	4.77**	6.37**	2.11*

*Significant at the 0.05 level **Significant at the 0.01 level
Figures given in the parenthesis are the square root transformed values

Table 4: Percent Disease Index of the observed disease in disease pest studies of Rapeseed crop

Treatments	Percent disease index (PDI)			
	20 DAS	40 DAS	60 DAS	80 DAS
Alternaria leaf blight				
Protected	1.85 (7.67)	4.81 (12.57)	10.14 (18.54)	12.66 (20.77)
Unprotected	2.81 (9.58)	15.18 (22.88)	22.74 (28.41)	25.33 (30.19)
Fisher (*t*)	2.22 (NS)	9.22**	7.66**	10.34**

*Significant at the 0.05 level **Significant at the 0.01 level
Figures given in the parenthesis are the angular transformed values

Table 5: Effects of weed, insect and pathogen pests on different growth attributes of Rapeseed crop

Treatments	Chlorophyll content (%)			Leaf area Index			Dry matter accumulation		
	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS	30 DAS	50 DAS	70 DAS
Weed experiment									
Protected	35.83	42.3	46.2	1.09	3.16	3.48	57.78	195.44	341.24
Unprotected	33.74	41.6	44.9	1.05	2.96	2.98	46.83	126.59	250.87
Fisher (*t*)	1.79 (NS)	0.42 (NS)	0.72 (NS)	0.25 (NS)	3.59*	8.02**	5.07*	8.65**	10.66*
Loss (%)	5.83	1.64	2.66	3.50	6.42	14.14	18.94	35.22	26.48
Insect experiment									
Protected	35.95	42.61	46.4	1.07	2.96	3.34	57.93	195.02	338.97
Unprotected	35.14	40.5	40.5	1.06	2.87	3.18	56.90	175.61	303.36
Fisher (*t*)	0.66 (NS)	1.54 (NS)	0.62 (NS)	0.15 (NS)	1.68 (NS)	2.16 (NS)	0.21 (NS)	3.12*	3.50*
Loss (%)	2.26	4.83	12.54	1.40	2.75	4.73	1.77	9.55	8.41
Disease experiment									
Protected	35.95	42.74	46.3	1.07	2.93	3.29	57.96	197.47	338.97
Unprotected	35.6	39.2	40.9	1.03	2.80	3.15	55.24	187.16	303.62
Fisher (*t*)	0.27 (NS)	2.39*	2.30*	0.26 (NS)	2.17 (NS)	2.96*	1.00 (NS)	1.93 (NS)	4.52*
Loss (%)	0.78	8.29	11.65	3.57	4.31	4.15	4.70	5.22	10.51

**Significant at the 0.01 level. NS- Not Significant

Table 6: Effects of weed, insect and pathogen pests on different yield attributes of Rapeseed crop

Treatment	Number of plants m^{-2}			Siliquae plant^{-1}			Seeds siliqua^{-1}		
	Weed	Insect	Disease	Weed	Insect	Disease	Weed	Insect	Disease
Protected	308	308	305	80.1	81.0	79.8	20.2	20.5	20.2
Unprotected	236	268	279	68.05	71.4	74.8	19.4	20.4	20.1
Fisher (*t*)	19.96**	8.16**	5.76**	10.62**	6.27**	3.84**	0.81^{NS}	0.08^{NS}	0.13^{NS}
Loss (%)	23.38	12.98	8.52	15.04	11.83	6.36	3.95	0.81	0.44
Treatment	Test weight (g)			Seed yield (t ha^{-1})			Stover yield (t ha^{-1})		
	Weed	Insect	Disease	Weed	Insect	Disease	Weed	Insect	Disease
Protected	5.21	5.18	5.10	6.16	6.20	6.02	45.90	45.51	45.87
Unprotected	3.29	3.73	4.29	4.73	5.07	5.28	41.15	42.39	44.95
Fisher (*t*)	10.47**	11.83**	6.94**	3.97**	5.31**	3.14**	3.28*	4.16**	0.90^{NS}
Loss (%)	37.02	27.90	15.60	23.12	18.23	12.35	10.36	6.86	2.04
Treatment	Harvest index (%)			Oil content (%)			Oil yield (t ha^{-1})		
	Weed	Insect	Disease	Weed	Insect	Disease	Weed	Insect	Disease
Protected	33.68	32.75	33.23	42.56	42.23	42.25	0.68	0.67	0.66
Unprotected	30.63	29.97	32.17	41.30	39.80	40.54	0.45	0.51	0.56
Fisher (*t*)	2.62*	3.18*	1.04 (NS)	2.49*	3.18*	2.47*	8.81**	9.74**	3.70*
Loss (%)	9.06	8.48	3.17	2.96	5.76	4.031	33.99	24.55	15.23

**Significant at the 0.01 level. NS- Not Significant

Table 7: Studies on correlation coefficients between the weed, insect &pathogen pest components with major crop growth and yield attributes

Traits	Weed biomass (g m^{-2})	Insect population	Disease PDI	LAI	DMA	No. of plants m^{-2}	No. of siliquae branch^{-1}	No. of seeds siliqua^{-1}	Test weight	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
Weed biomass (g m^{-2})	1										
Insect population	-0.699*	1									
Disease PDI	-0.616*	-0.463	1								
LAI	-0.692*	-0.748*	-0.722*	1							
DMA (g m^{-2})	-0.536*	-0.637*	-0.611*	0.707*	1						
No. of plants m^{-2}	-0.837**	-0.436	-0.559	0.242	0.722*	1					
No. of siliquae branch^{-1}	-0.591	-0.486	-0.327	0.725	0.552	0.338	1				
No. of seeds siliqua^{-1}	-0.591	-0.617*	-0.657*	0.580	0.464	0.586	0.230	1			
Test weight	-0.360	-0.445	-0.419	0.517	0.421	0.359	0.461	0.384	1		
Seed yield(t ha^{-1})	-0.790**	-0.765**	-0.699**	0.851*	0.710*	0.726**	0.862**	0.948**	0.444	1	
Stover yield(t ha^{-1})	-0.742**	-0.797**	-0.785**	0.711*	0.755*	0.686*	0.747*	0.870*	0.753*	0.609*	1

Conclusion

The extent of losses for rapeseed under prevailing weed and pest scenario is offered most by weeds (23.23% in seed and 33.99% in oil yield) followed by insect pest (18.23% in seed and 24.55% in oil yield) and disease pest (12.35% in seed and 15.23% in oil yield) and how ecosafe management options respond to crop - pest completion. The correlation study (Table 7) with the three major pests' weed (density and biomass), insect (density) and disease (PDI) with major growth and yield attributes and the biological yields revealed the following: The proper ecosafe management in time of critical infestation of pests like in weed pest initial one month; for aphid insect & blight disease pest above 40 days.

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