In the present investigation, Neemazal was found to be most effective against mustard aphid as compared to Nimbecidine and Neemgold. After one day of first spraying Neemazal reduced the aphid population by 28.52 and 27.80 per cent during 1998-99 and 1999-2000, respectively. The effectiveness of Nimbecidine in the reduction of aphid population after one day of first spraying was 20.34 and 23.16 per cent during 1998-99 and 1999-2000 (Table 1 and 2), respectively. The least effective treatment was Neemgold which reduced the aphid population by 17.19 and 20.33 per cent during 1998-99 and 1999-2000, respectively. After seven days of first spraying, Neemazal, Nimbacidine and Neemgold reduced the aphid population by 57.79, 54.57 and 51.19 per cent, respectively, during 1998-99 while during 1999-2000 it was 58.83, 53.35 and 52.06 per cent, respectively. The present findings are in comformity with that of Debraj *et al.* (1996) who reported officacy of Nimbecidine against *B. brassiciae*.Dhaliwal et al. (1998) also reported that 84.02 per cent mortality of *L.erysimi* on cabbage was found due to Nimbecidine after seven days of spraying. Manger et al. (1996) also reported the effectiveness of Neemazal against *B.brassicae*. Koul et al. (1997) found that neem seed extracts were highly deterrent to *B.brassicae*. Opender (1998) found that neem seed extract and azadirachtin reduced the fertility and fecundity. All these findings support the present work on the effect of different neem formulations against mustard aphid, *L.erysimi*, on cabbage. Thus the use of neem formulations should be made on cabbage in order to reduce the load of pesticides in environment and to conserve the natural enemies which are otherwise lilled by the toxic pesticides.

REFERENCES

Debraj J, Singh M P and Singh T K. 1996. Laboratory testing of some insecticides and neem products against cabbage aphid. *Brevicoryne brasicae* (L.). *Annals of Plant Protection Sciences,* **4**: 174-175.

Dhaliwal G S, Gill R S and Dilwari V K. 1998. Management of insect pest complex of cabbage with neem based insecticides. In: Dhaliwal G S, Arora R, Randhawa N S and Dhawan A K (eds.) Ecological agriculturte and sustainable development. Proceeding of International Congerence on Ecological Agriculture towards sustainable development, Chandigarh, India, 15-17 Nov, 1997, 2: 306-314.

Flemming R and Retnakaran A. 1985. Evaluating single treatment data using Abbot's formula with reference to insecticides. *Journal of Econnomic Entomology,* **78**: 1179-1181.

Koul O, Shankar J S and Mehta N. 1997. Antifeedant activity of neem seed extracts and azadirachtin to cabbage aphid, *Brevicoryne brassica* (L.). *Indian Journal of Experimental Biology,* **35**: 994-997.

Lal O P. 1996. Integrated pest management for sustained crop production. In: N K Roy (ed.) Agrochemicals and sustainable agriculture, APC Publications Pvt. Ltd., 29-44.

Manger W, Koeckhoven J and Keeberg H. 1996. Control of insects in Brussels sproots with neemzal T/S. In : C.P.W. Zebitz (ed.) Practice oriented results on use and production of neem, ingradients and pheromones. Proceeding 5th workshop wetzlar, Germany, 22-25 January, 1996.

Opender K. 1998. Effect of neem extract and azadirachtin on fertility and fecundity of cabbage aphid, *Brevicoryne brassicae* (L.). *Pesticide Research Journal*, 10: 258-261.

Saxena R C. 1989. Insecticides from neem. In: *Azadiraclita indica,* A. Juss, and other meliaceous plants: source of unique natural products for integrated pest management medicine, industry and other purposes. VCH, Weinheim.

Schmutterer H. 1990. Properties and potential of natural pesticides from the neem tree. *Azadirachta Indica. Annual Review of Entomology,* **35**: 271-297.

****

Strategic IPM interventions for management of Sclerotinia rot in oilseed Brassicas

M S YADAV[1], NASIM AHMAD[1], NAVEEN SINGH[2], D K YADAVA[2], S GODIKA[3] J L YADAV[4] AND C CHATTOPADHYAY[1]

[1]ICAR-National Research Centre for Integrated Pest Management, LBS Building, New Delhi-110 012,[2]Division of Genetics, ICAR-IARI, New Delhi, [3]SKNAU, ARS, Navgaon, Alwar and [4]CCSHAU, KVK Mohindergarh, Haryana
Email: dr.msyadav65@gmail.com

The explosive Pathogenicity of *Sclerotinia sclerotiorum (Lib.*) de Bary causing rot in oilseed Brassicashas made it very difficult to guard the crop from its infection in India, where it causes seed yield losses up to 74%. Identification of improved source of resistance is an important prerequisite for disease management but only resistance breeding is not

able to keep pace with the development of this virulent pathogen. *Trichoderma* has been found effective against *S. Sclerotiorum* of Indian mustard. Therefore, field studies were conducted for evaluation of efficacy of *Trichoderma harzianum*. Field studies consisting of six different treatments in RBD, four on the basis of different combination of *T. harzianum* (PCI strain), standard fungicide control, carbendazim along with untreated control was conducted using variety Rohini with *T. harzianum* ($2x10^6$ c.f.u./g) during r*abi* season of 2011-12 and 2012-13. Field experiments were also conducted in IARI, New Delhi for virulence assessment of 70 genotypes under artificial Sclerotinia rot development conditions. Similarly, large scale multilocational validation of strategic IPM interventions was conducted against Sclerotinia rot at 188 locations in Haryana and Rajasthan on 117 ha, which were identified for assured incidence of *Sclerotinia* rot on farmers' fields in Alwar, Rajasthan and Mewat and Mohindergarh district in Haryana from *rabi* 2011-12 to 2013-14.Out of four different combination of *T. harzianum* (PCI strain), least (4.2%) Sclerotinia rot incidence was found in combination of seed treatment @10g/kg, soil application @ 2.5 kg/ha and two foliar sprays of *T. harzianum* @ 0.2% at 50 and 70 days after sowing and gave maximum seed yield (2080 kg/ha.). In virulence assessment studies, eight genotypes *viz*., Pusa Aditya, NPC 16, DMH 1, HYT 8, Pusa Swarnim, RGN 73, Bio-YSR and EJ 15 having < 5% incidence and low severity (0-1 grade) were rated as tolerant. The strategic IPM interventions (cultural practices as well as *T. harzianum,* $2x10^6$ cfu/g, PCI strain) conducted on large scale in three districts comprising state of Haryana and Rajasthan, includes improved cultural practices *viz*., deep summer ploughing, preparation of levelled and well drained field, balanced use of nitrogenous fertilizers, sowing from 16 - 31 Oct, use of clean and certified seed along with soil application of Potash (K_2O) @ 40.0 kg, Sulphur @ 40.0 kg and *T. harzianum* ($2x10^6$c.f.u./g) @ 2.5kg/ha pre-incubated in 50 kg well rotten FYM followed by seed treatment with *T. harzianum* @ 10g/kg, maintenance of optimum plant population with wide spacing, judicious use of irrigation water at different crop stages. The strategic IPM interventions were found better over Farmers's practices (FP) in reducing the disease incidence atvillages Sali Khurd in Alwar, Rajasthan, Dingerheri in Mewat; Kakarala and Khampura in Mohindergarh, Haryana and finally increasing the mean seed yield over farmers's practices. In strategic IPM interventions tolerant host plant along with improved cultural practices as well as all possible combinations of *T. harzianum,* $2x10^6$ cfu/g, reduced the disease incidence and increased the seed yield. In large-scale multilocational validation of these strategic IPM interventions was appreciated by farmers. This strategy is expected to reduce the indiscriminate use of chemical pesticide and safeguard the other beneficial microbes.

India is a leading producer of oilseed Brassicas contributing approximately 26.1 and 29.1% in area and production, respectively. The explosive Pathogenicity of *Sclerotinia sclerotiorum* causing rot in oilseeds Brassicas has made it very difficult to guard the crop from its infection in India. It is a major problem of Brassicas where farmers practiced monocroping of mustard, which lead to disastrous crop failure with more than 80% disease incidence in north and north-western India which indicates the importance of the disease, Yadav *et al.* (2012a and 2013). Although some partial resistance to *S. sclerotiorum* has been identified by Goyal *et al.* (2011) but only resistance breeding is not able to keep pace with the development of this virulent pathogen. *Trichoderma* has been found effective against *S. Sclerotiorum* of Indian mustard both in *in vitro* and *in vivo* by Yadav *et al.* (2011 and 2012a). Field studies were conducted for evaluation *T. harzianum* (PCI strain) in different combinations along with identification of sources of resistance against *S. sclerotiorum* in IARI, New Delhi and large-scale multilocational validation of strategic IPM interventions in farmer participatory mode on farmers' fields in Haryana and Rajasthan states.

Evaluation of efficacy of combinations of *T. harzianum* against *S. sclerotiorum*

Field studies consisting of six different treatments in RBD (Table 1), four on the basis of different combinations of *T. harzianum* (PCI strain), standard fungicide control, carbendazim along with untreated control was conducted using variety Rohini with *T. harzianum* ($2x10^6$ c. f. u./g) during *Rabi* season 2011-12 and 2012-13 in IARI, New Delhi. Sowing has been done on 16 Nov. Artificial inoculation of soil with *S. sclerotiorum*, cultural practices, observations of disease incidence and yield data were followed as per Yadav *et al.* (2012).

Virulence assessment of elite genotype against *S. sclerotiorum*

Field experiments were also conducted in IARI, New Delhi for virulence assessment of 70 genotypes under artificial *Sclerotinia* development conditions from *rabi* 2011-12 to 2013-14. Artificial inoculation of soil, stem as well as cultural practices and data recording were carried out as per Yadav *et al.* (2012b).

Large scale multilocational validation of strategic IPM interventions against *S. sclerotiorum*

Large scale multilocational validation of strategic IPM interventions was conducted against Sclerotinia rot at 188 locations in Haryana and Rajasthan on 117 ha, which were identified for assured incidence of Sclerotinia rot on farmers' fields in Alwar, Rajasthan and Mewat and Mohindergarh district of Haryana from rabi 2011-12 to 2013-14 in collaboration

with ARS, Navgaon, Alwar of SKNAU and *KVK*s of CCSHAU. The strategic IPM interventions includes improved cultural practices *viz*., deep summer ploughing, preparation of level and well drained field, balanced use of nitrogenous fertilizers, sowing from 16-31 Oct, use of clean and certified seed along with soil application of potash (K_2O) @40.0 kg, Sulphur @40.0 kg and *T. harzianum* ($2x10^6$c.f.u./g)@ 2.5kg/ha pre-incubated in 50 kg well-rotten FYM followed by seed treatment with *T. harzianum* @ 10g/kg, maintenance of optimum plant population with wide spacing, judicious use of irrigation water at different crop stages. The observations for per cent incidence of *Sclerotinia* rot on stem were recorded 20days before the majority of crop.

Evaluation of efficacy of combinations of *T. harzianum* against *S. sclerotiorum*

Sclerotinia rot incidence (Table 1) over the years was least (4.2%) with maximum seed yield (2080 kg/ha) in *T. harzianum* based treatment, T_3 (seed treatment @ 10g/kg, soil application @ 2.5 kg/ha and two spray @ 0.2%) at 50 and 70 days after sowing), which reduced the disease incidence over all other treatments and increased the seed yield (2080kg/ha) over control (1146 kg/ha). Seed treatment with *T. harzianum* (10g/kg) followed by spray of *T. harzianum* @ 0.2% at 50 and 70 DAS based treatment (T_4) was found inferior (11.3% disease incidence) to standard fungicide carbendazim (9.9%), seed treatment and two spray @ 0.2% (T_5). Maximum disease incidence (14.3%) in control. Gaur *et al*. (2010) reported that seed treatment @10g/kg and one foliar spray @ 0.2% with mixed formulation of *T. hamatum* + *T. viride* gave minimum *Sclerotinia* incidence (5.8%) and maximum yield (2.27 tonnes/ha) over rest of treatments. In our studies, combinations of soil application of *T. harzianum* @2.5 kg/ha pre-incubated in 50 kg well-rotten FYM has shown better results.

Table 1: Disease incidence (%) of *Sclerotinia* rot and seed yield under artificial disease development conditions at IARI, New Delhi during 2011-12 and 2012-13.

Treatment	Disease incidence (%)			Seed Yield (kg/ha)		
	2011-12	2012-13	Mean	2011-12	2012-13	Mean
T_1 = Soil application of *T. harzianum* @2.5 kg/ha	10.9	7.2	9.1	1815	1789	1802
T_2 = Seed treatment with *T. harzianum* @ 10g/kg + soil application @2.5 kg/ha	8.1	4.2	6.2	1993	1989	1991
T_3 = Seed treatment with *T. harzianum* @ 10g/kg + soil application @2.5 kg/ha + two spray @ 0.2% at 50 and 70 day after sowing (DAS)	4.2	4.3.	4.2	2111	2049	2080
T_4 = Seed treatment with bioagent *T. harzianum* @ 10g/kg + two spray @ 0.2% at 50 and 70 day after sowing	14.5	8.1	11.3	1556	1522	1539
T_5 = Seed treatment with carbendazim @2g/kg + spray of carbendazim @0.2% at 50 and 70 DAS	12.1	7.6	9.9	1700	1678	1689
T_6 = Untreated seed and water spray at 50 and 70 day after sowing	19.4	9.2	14.3	1159	1133	1146

Virulence assessment of elite genotype against *S. sclerotiorum*

Out of 70 elite genotypes, none has shown immune to *S. sclerotiorum* (Table 2).In final evaluation of virulence assessment, eight genotypes *viz*., Pusa Aditya, NPC 16, DMH 1, HYT 8, Pusa Swarnim, RGN 73, Bio-YSR and EJ 15 having < 5 per cent incidence and low severity (0-1 grade) were rated as tolerant, whereas twenty one have showed 5 -10 per cent

Table 2: Disease reaction of elite genotypes and notified varieties of Brassicas against *S. sclerotiorum* under sick field conditions

Disease reaction	Number of genotypes	Name of genotype/Variety
T= < 5% disease incidence	08	Pusa Aditya, NPC 16, DMH 1, HYT 8, Pusa Swarnim, RGN 73, Bio-YSR and EJ 15.
MT = 5 – 10.0% incidence	21	Pusa Tarak, NRCHB 506, NRCHB 101, Pusa Mustard 24, Pusa Mustard 25, Pusa Mustard 26, Pusa Jagannath, RGN 48, Pusa Vijay, Pusa Mahak, Pusa Agrani, Pusa Jaikisan, NRCDR 02, NPJ 157, NPJ 158, NPJ 159, NPJ 161, NPJ 162, NPJ 164, NPJ 165 and NPJ 167

T = Tolerant, MT = moderately tolerant

incidence were found moderately tolerant. Li *et al* (2007) emphasized the importance of type and time of inoculation and assessment in determination of resistance in *Brassica napus* and *B. juncea* to *S. sclerotiorum.* Yadav *et al.* (2012) reported that four varieties viz., Pusa Aditya, Kiran, Pusa Krishma and RLM 619 have less than 5% incidence and low severity (0-1 grade) were rated as tolerant. The genotypes which were found tolerant can be tested for resistant breeding programme.

Large scale validation of strategic IPM interventions against *S. sclerotiorum*

Strategic IPM interventions of Sclerotinia rot was found better over Farmers' practices (FP) in reducing the mean disease incidence from 24.2 to 7.5%in Mewat region of Haryana and finally increasing the mean seed yield over farmers' practices from 12.7 to 17.2q/ha (Table 3). In Mohindergarh district of Haryana, Sclerotinia rot mean incidence reduced to 7.4 from 32.1% with corresponding increase in mean seed yield to 18.1 from 13.2q/ha. The strategic IPM has also performed very well on 36 ha in Alwar, Rajasthan, where mean Sclerotinia rot incidence reduced to 11.4 from 30.4% with corresponding increase in mean seed yield to 17.0 from 13.2q/ha. Sharma *et al.* (2001) also observed the effect of various agronomic practices such as crop rotation, number of irrigations on incidence of white rot of Indian mustard caused by *S. sclerotiorum*. These results are in agreement with Meena *et al.* (2013), where use of *Trichoderma* as seed treatment and foliar spray reduced the disease and increase the yield. Sclerotinia rot attack is gradually increasing at farmers 'fields in Haryana.

Table 3: Sclerotinia incidence and seed yield under strategic IPM and farmer practices interventions in mustard (pooled mean of 2011-12, 2012-13 & 2013-14) in Haryana and Rajasthan

Intervention	Sclerotinia rot (%)				Seed Yield (q/ha)			
	2011-12	2013-13	2013-14	Mean	2011-12	2013-13	2013-14	Mean
Mewat region								
I. Strategic IPM	5.0	2.5	15.0	7.5	19.5	15.6	16.4	17.2
II. Farmers' practice	12.5	10.0	50.0	24.2	13.3	14.0	10.8	12.7
Mohindergarh region								
I. Strategic IPM	3.1	11.0	8.0	7.4	19.0	17.9	17.3	18.1
II.Farmers' practice	16.9	31.8	47.5	32.1	15.2	15.1	9.3	13.2
Alwar region								
I. Strategic IPM	5.0	17.8	11.3	11.4	18.3	15.6	17.0	17.0
II Farmers' practice	11.4	41.4	38.4	30.4	15.4	13.6	10.5	13.2

REFERENCES

Gaur R B, Sharma R N, Gautam V S and Dangi R P. 2010. Management of *Sclerotinia* rot of mustard through bioagent. *Indian Phytopathology*, **63**: 392-397.

Goyal P, Chahar M, Barbetti MJ, Liu SY and Chattopadhyay C. 2011. Resistance to *Sclerotinia* rot caused by *Sclerotinia sclerotiorum* in *Brassica juncea* and *B. napus* germplasm. *Indian Journal of Plant Protection*, **39**: 60-64.

Li C X, Li Hua, Siddique AB, Sivasithamparam K, Salisbury P, Banga S S, Banga S, Chattopadhyay C, Kumar A, Singh R, Singh D, Agnihotri A, Liu S Y, Li Y C, Tu J, Fu T D, Wang Y F and Barbetti M J. 2007. Importance of the type and time of inoculation and assessment in determination of resistance in *Brassica napus* and *B. juncea* to *Sclerotinia sclerotiorum*. *Australian Journal of Agricultural Research*, **58**: 1198-1203.

Meena P D, Gaur R B, Gupta J C, Singh H K, Awasthi R P, Netam R S, Godika S, Sandhu P S, Prasad R, Rathi A S, Rai D, Thomas L, Patel G A and Chattopadhyay C. 2013. Non-chemical agents provide tenable, eco-friendly alternatives for the management of the major diseases devastating Indian mustard (*Brassica juncea*) in India. *Crop Protection*, **53**: 169-174.

Sharma S K, Yadav J L and Sharma G R. 2001. Effect of various agronomic practices on incidence of white rot of Indian mustard caused by *Sclerotinia sclerotiorum*. *Journal of Mycology and Plant Pathology*, **31**: 83-84.

Yadav M S, Ahmad N, Singh S, Bambawale O M and Yadava D K. 2011. Evaluation of *Trichoderma* and garlic clove extract against *S.sclerotiorum* of *Brassica juncea*. *Indian Phytopathology*, **64**: 305-307.

Yadav M S, Ahmad N, Singh S, Yadav D K, Godika S and Gaur R B. 2012. Multilocational validation of integrated management practices for *Sclerotinia* rot Indian mustard. *Indian Journal of Agriculture Sciences*, **82:** 972-977.

Yadav, M.S., Singh, N., Ahmad, N., Yadava, D.K., Singh, S. and Bambawale, O.M. 2012b. Sources of resistance to *Sclerotinia sclerotiorum* in Indian varieties of rapeseed-mustard. Plant Disease Research 27: 108-110. Yadava, D.K.

Yadav, M.S., Singh, N., Singh, S., Ahmad, N. and Godika, S.2013. Assessment of prevalence and severity of *Sclerotinia* rot of Indian mustard in Rajasthan and Haryana. Indian Journal of Plant protection 41: 249-252.

****