

Integrated pest management in barley (*Hordeum vulgare*)*

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Barley (*Hordeum vulgare* L.) is an important winter cereal crop in India and is grown in northern hills, plains and central India for food, feed and industrial purposes (for malt). The crop is inherited with better tolerance to soil salinity, less water requirements and fertilizers than the wheat. Traditionally, barley has been perceived a crop of comparatively poor and marginal lands with low fertility and restricted irrigation for use as animal feed. However, during past 2 decades, the situation has changed and besides feed, it has emerged as industrial crop for malt purposes and now being grown under contract farming in high fertility and assured irrigation conditions. The shift in cultivation in such conditions also provided conducive microclimate for the attack and spread of some diseases and insect pests and their incidence has increased. It has therefore affected the yield as well as quality of grains. Keeping this in view, an integrated management of insect pests and diseases was attempted in a module format at multi-location.

The experiments were conducted during 2005–07 crop seasons at Ludhiana (Punjab), Karnal and Hisar (Haryana) in north-western plains zone (NWPZ) and Dharwad (Karnataka) in peninsular zone (PZ), by taking malt 'DWR 28' variety, whereas feed barley 'Jyoti' variety was taken at Faizabad (Uttar Pradesh) in north-eastern plains zone (NEPZ), respectively. The experiment was conducted in completely randomized block design and each treatment was

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replicated thrice. The plot was having 6 rows of 4 m length at 25 cm apart from each other. In 6 treatments, a uniform dose of fertilizers NPK @ 80:30:20 kg/ha was applied. Half of N and full dose of P and K was applied as basal dose at the time of sowing in whole field to be used for experimentation. The second half of N was given as broadcast after 30–35 days of sowing at first irrigation. In one treatment double (40 kg/ha) the recommended dose of K was applied. Likewise, Phorate (Thimet® 10G) @ 10 kg/ha was also applied at sowing in one treatment. The other treatments include seed treatment and foliar sprays of carboxin (Vitavax power®) @ 3.0 g/kg of seed, imidacloprid (Gaucho® 70WS) @ 0.6 g a i/kg, spores of *Trichoderma harzianum* (isol. DWRLB 1) @ 5 g/kg of seed, foliar sprays of propiconazole (Tilt® 25 EC) @ 0.1%, imidacloprid (Confidor®) @ 20 g a i/ha and spore suspension of *T. harzianum* @ 10⁴ spores/ml and azadirachtin (Econeem®) 10 000 ppm @ 0.3%. The seed treatment was given at sowing, whereas foliar sprays were given at initiation of symptoms of diseases and appearance of aphids so as to reduce the dosage of insecticides. Three foliar sprays of propiconazole were given at 15 days interval, whereas only one spray of imidacloprid was given. The details of treatments are given in Tables 1–3. The data on dates of sowing, appearance of first symptom of rusts, foliar blights, appearance of foliar aphids, numbers covered smut affected and healthy tillers/plot, rust and foliar blight incidence (0–9 scale in dd at F and F-1 leaves), incidence of aphids (1–5 scale) at hard dough stage, yield/plot and 1000-grain weight. The record on rusts was taken by taking both severity (Traces to 100) on plants denoted by per cent leaf area covered and host responses (R, MR, S, MS and X) following the method given by Joshi *et al.* (1986). The data were analyzed statistically.

The productivity during 2005–06 was higher in NEPZ, whereas it was higher during 2006–07 at Dharwad due to weather factors. The leaf blight occurred naturally at all the testing centres and given in Tables 2, 3 along with grain yield data.

Table 1 Effect of different treatments on leaf and stripe rusts and covered smut incidence in barley during 2005–06 and 2006–07 crop seasons

Treatments	North-western plains zone			Peninsular zone			North-western plains zone			Mean						
	Stripe rust score			Stem rust score			Nos. of infected tillers due to covered smut									
	Karnal	Hisar	Ludhiana	Ludhiana	Dharwad	Dharwad	Karnal	Hisar	Ludhiana							
Untreated control, N80:P30:K20 kg/ha	0	5 MS	TS	40S	15 S	5S	20S	20S	20S	1.01	1.90	12.09	1.30	0.39	0.04	2.79
N80:P30:K40 kg/ha	0	5 MS	TS	30S	15 S	TS	20S	20S	20S	0.89	1.80	12.06	0.60	0.56	0.06	2.67
ST Vitavax power @ 3g/kg and imidacloprid (Confidor) @ 0.6g a i/kg.	0	0	TS	20S	15 S	TS	20S	5S	5S	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ST Vitavax and imidacloprid + soil placement of Phorate @ 10 kg/ha.	10 MS	0	TS	20S	10 S	TS	10S	5S	5S	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ST Vitavax and imidacloprid + S propiconazole (Tilt 25 EC) @ 0.1% and imidacloprid (Confidor) @ 20 g a i/ha	0	0	0	TS	5 S	0	10S	5S	5S	0.01	0.00	0.00	0.00	0.00	0.00	0.00
ST Vitavax and imidacloprid + S imidacloprid	0	TMS	0	40S	15 S	TS	10S	10S	10S	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ST spores of <i>Trichoderma harzianum</i> (isol. DWRLB 1) @ 5 g/kg of seed, S of <i>T. harzianum</i> @ 10 ⁴ /ml and Econeem @ 0.3%. CD (<i>P</i> =0.05)	0	10 MS	TS	30S	15 S	TS	10S	20S	20S	0.32	1.20	2.05	0.40	0.63	0.01	1.37

S, Foliar sprays; ST, pre-sowing seed treatment; TS, traces; S, susceptible; MS, moderately susceptible; NS, non-significant

Table 2 Effect of different treatments on leaf blight incidence and yield parameters in barley during 2005–06 and 2006–07

Treatment	North-eastern plains zone				North-western plains zone				Peninsular zone		
	Faizabad		Karnal		Hisar		Ludhiana		Dharwad		
	LBS on 'Jyoti' (0–9 dd)	Yield (tonnes/ha)	Per cent gain over control	LBS on 'DWR 28'	Yield (tonnes/ha)	LBS on 'DWR 28'	Yield (tonnes/ha)	LBS on 'DWR 28'	Yield (tonnes/ha)	Per cent gain over control	
2005–06											
Untreated control, N80:P30:K20 kg/ha	69	1.92		23	2.83	23	2.37	68	2.71	23	2.26
N80:P30:K40 kg/ha	67	1.99	3.6	23	2.63	35	2.12	38	3.27	23	1.97
ST Vitavax power @ 3g/kg & imidacloprid (Confidor) @ 0.6g a i/kg.	47	2.09	8.9	12	3.37	12	2.67	25	2.81	23	3.39
ST Vitavax and imidacloprid + soil placement of Phorate @ 10 kg/ha.	45	2.09	8.9	03	3.27	02	2.25	38	3.03	23	2.71
ST Vitavax and imidacloprid + S propiconazole (Tilt 25 EC) @ 0.1% and imidacloprid (Confidor) @ 20 g a i/ha	23	2.34	21.9	13	3.22	02	2.96	23	3.58	12	3.32
ST Vitavax and imidacloprid + S imidacloprid	45	2.05	6.8	25	3.18	12	3.25	17	3.48	15	2.19
ST spores of <i>Trichoderma harzianum</i> (isol. DWR LB1) @ 5 g/kg, S of <i>T. harzianum</i> @ 10 ⁴ /ml and Econeem @ 0.3%.	36	2.00	4.2	24	3.72	12	2.87	15	2.93	12	2.05
CD (<i>P</i> =0.05)		0.18			NS		0.77		0.65		0.75
2006–07											
Untreated control, N80:P30:K20 kg/ha	68	1.83		46	2.13	23	2.25	57	2.83	45	2.34
N80:P30:K40 kg/ha	68	1.91	4.4	35	2.07	12	2.72	37	2.89	34	3.36
ST Vitavax power @ 3g/kg and imidacloprid (Confidor) @ 0.6g a i/kg.	45	2.02	10.4	13	2.80	12	2.39	37	3.17	34	3.67
ST Vitavax and imidacloprid + soil placement of Phorate @ 10 kg/ha.	45	2.05	12.0	24	2.95	12	2.81	37	3.45	24	3.53
ST Vitavax and imidacloprid + S propiconazole (Tilt 25 EC) @ 0.1% and imidacloprid (Confidor) @ 20 g a i/ha	13	2.37	29.5	02	3.03	02	3.42	23	4.33	24	3.63
ST Vitavax and imidacloprid + S imidacloprid	34	2.08	13.7	13	3.29	02	3.06	27	3.25	14	3.49
ST spores of <i>Trichoderma harzianum</i> (isol. DWR LB1) @ 5 g/kg, S of <i>T. harzianum</i> @ 10 ⁴ /ml and Econeem @ 0.3%.	23	2.15	17.5	35	2.54	12	2.36	46	2.89	34	2.95
CD (<i>P</i> =0.05)		0.16			0.80		0.49		0.44		0.33

LBS, Leaf Blight Score; S, foliar sprays; ST, pre-sowing seed treatment

Table 3 Influence of different treatments on 1 000-grain weight and insect pests in barley during 2005–06 and 2006–07 crop seasons

Treatment	1 000-grain wt (g)												Termites infested tillers/plot						
	North-eastern plains zone				North-western plains zone				Peninsular zone				North-western plains zone						
	Faizabad	Karnal	Hisar	Ludhiana	Karnal	Hisar	Ludhiana	Mean	Dharwad	Mean	Karnal	Karnal	Hisar						
Untreated control,	37.5	36.6	37.1	55.1	52.3	52.8	45.9	58.5	47.9	52.1	51.6	53.5	52.6	7.3	17.3	527	523	153	72
N80:P30:K20 kg/ha																			
N80:P30:K40 kg/ha	38.0	37.0	37.5	56.8	52.0	53.0	46.1	58.4	47.5	52.3	51.0	53.7	52.4	13.7	22.3	406	551	155	74
ST Vitavax power @ 3g/kg and imidacloprid (Confidor) @ 0.6g a i/kg.	38.2	37.3	37.8	54.6	52.3	54.0	45.0	58.8	49.4	52.4	52.3	55.2	53.8	13.7	9.0	412	458	51	67
ST Vitavax and imidacloprid + soil placement of Phorate @ 10 kg/ha.	38.1	37.4	37.8	56.3	52.3	52.0	47.1	57.6	49.1	52.4	52.3	55.3	53.8	4.3	7.7	455	452	100	65
ST Vitavax and imidacloprid + S propiconazole (Tilt 25 EC) @ 0.1% and imidacloprid (Confidor) @ 20 g a.i./haa	40.1	40.1	40.1	55.4	54.3	57.3	50.0	51.2	49.8	53.0	51.3	55.1	53.2	12.3	14.7	417	425	74	50
ST Vitavax and imidacloprid + S imidacloprid	38.1	37.4	37.8	54.9	54.3	62.9	48.4	60.3	48.7	54.9	50.3	54.7	52.5	13.7	14.7	457	356	66	56
ST spores of <i>Trichoderma</i> <i>harzianum</i> (isol. DWR LB1) @ 5 g/kg, S of <i>T. harzianum</i> @ 10 ⁴ /ml and Econeem @ 0.3%.	38.9	38.1	38.5	55.5	52.7	50.9	48.8	57.1	48.0	52.2	49.6	53.7	51.7	18.7	11.3	462	384	153	72
CD ($P=0.05$)	2.4	1.1		5.1	3.5	5.3	0.15	4.3	1.6		NS	1.6		12.5	NS	70	NS	21	16

The diseases recorded in NWPZ were leaf blight, stripe rust and covered smut, whereas insects were termites and foliar aphids on malt barley 'DWR 28' variety. The incidence of leaf blight was also recorded at Faizabad centre in NEPZ and at Dharwad in PZ. Stem rust also recorded at Dharwad. During 2005–06 and 2006–07 crop seasons, leaf blight score range was highest in untreated control (68–69) in NEPZ as compared to NWPZ (23–68) and PZ (23–34). The score of leaf blight on flag and penultimate leaves was reduced considerably due to spray of propiconazole (0.1%) and score was reduced to the range of 02–23 (Tables 2, 3). The stripe rust could develop at Karnal, Ludhiana and Hisar centres in NWPZ in the range of TS–40S during 2 crop seasons (Table 1). The score of stripe rust was reduced in the range of 0–5S at different centres due to foliar sprays of propiconazole. The stem rust score was 20S in untreated control and reduced to 5–10S due to foliar sprays of propiconazole. The percentage of covered smut was in the range of 1.01–12.09 with a mean value of 2.79 during 2005–06 and 2006–07 in untreated control at Karnal, Ludhiana and Hisar centres (Table 1) which was controlled fully due to seed treatment with Vitavax power. Beniwal and Mehta (2008) reported that triademenol and tebuconazole were highly effective in reducing smut of barley. The seed treatment with *T. harzianum* also reduced the mean incidence up to 1.37%. The effect of higher doses of K was not significant on covered smut. Singh (1999) conducted field trials at Karnal for chemical and biological control of covered smut of barley caused by *Ustilago hordei* and found that the seed treatment with carboxin (Vitavax) at 0.25%, carbendazim at 0.25% or tebuconazole at 0.15%, wet treatment with carboxin at 0.125%, carbendazim at 0.125% or tebuconazole at 0.075% and treatment with spores of *Trichoderma viride*. Infection of *U. hordei* was eradicated completely in all the fungicidal treatments as well as the *T. viride* treatments.

The record on incidence of termites and foliar aphids was taken at Karnal, whereas Hisar centre took the data on

incidence foliar aphids only. The incidence of termites was reduced maximum in case of seed treatment with imidacloprid (Gaucho) and soil application of phorate. The incidence of foliar aphids was reduced significantly due to seed treatment with imidacloprid, followed by spray of same. Babu *et al.* (2006) reported that the sprays of imidacloprid @ 20 g ai/ha were highly effective in suppressing the foliar aphids of barley. Indira Rajvanshi (2003) carried out studies on the management of cereal cyst nematode, *Heterodera avenae*, infesting barley by integrating ecofriendly components such as biological control agent (*Trichoderma viride*), compost (farmyard manure) and a nematicide (carbofuran 3G). Among the different treatments, farmyard manure + reduced dose of carbofuran 3G at 0.5 kg ai/ha+*T. viride* was most effective in reducing the nematode population and increasing grain yield.

The grain yield increased significantly as compared to untreated control in all the treatments except use of higher K at Faizabad in NEPZ during both the crop seasons and it increased the yield ranging from 3.6 to 29.5%. Amongst treatment, the best yield gain was in case of seed treatment with Vitavax power and imidacloprid, followed by foliar sprays of propiconazole and imidacloprid and was 21.9 and 29.5%, during 2005–06 and 2006–07, respectively. Singh (2004) found that the seed treatment of barely with tebuconazole combined with 2 foliar sprays of propiconazole increased the grain yield, number of grains/ear-head and 1000-grain weight, significantly. The above treatment was also proved best and significantly increased the grain yield in both years at Karnal, Ludhiana and Hisar in NWPZ and Dharwad in PZ. The increase in grain yield on an average was 23.1 and 49.6% during 2005–06 and 2006–07, respectively in NWPZ, whereas it was 46.9 and 55.1% respectively in PZ (Tables 2, 3). Thousand grain weight was also increased significantly due to seed treatment of Vitavax power and imidacloprid, followed by foliar sprays of propiconazole and imidacloprid, as compared to untreated

Table 4 Cost : benefit ratio of most effective treatment in IPM in barley

Treatment	Crop year	Cost of critical inputs (Rs./ha)	Cost of yield gained (Rs/ha)			Net profit/ha (Rs)			Cost:benefit ratio		
			North-eastern plains zone	North-western plains zone	Peninsular zone	North-eastern plains zone	North-western plains zone	Peninsular zone	North-eastern plains zone	North-western plains zone	Peninsular zone
ST Vitavax power and imidacloprid + S	2005–06	1 320	3 150	4 270	7 420	1 830	2 950	6 100	1.0:2.4	1.0:3.2	1.0:5.6
propiconazole (Tilt 25 EC) @ 0.1% and imidacloprid (Confidor) @ 20 g a i/ha	2006–07	1 320	4 050	8 925	9 675	2 730	7 605	8 355	1.0:9.1	1.0:6.8	1.0:7.3

Cost of 3 foliar sprays of propiconazole (Tilt 25 EC) @ 250 ml/ha=Rs. 600, Cost of seed treatment of Vitavax power @ 250 g/100 kg seed = Rs. 250/-, Cost of Imidacloprid ST =Rs. 1,200/ ha, Cost of Imidacloprid (Confidor) spray= Rs. Rs 470/ha, Market cost of feed and barley grains @ Rs. 700 and Rs. 750/100 kg during 2005–06 and 2006–07 respectively.

control during 2005–06 and 2006–07 at all the 5 centres in NEPZ, NWPZ and PZ (Table 3).

The application of seed treatment with Vitavax power and imidacloprid, followed by foliar sprays of propiconazole and imidacloprid resulted a net profit of Rs 1 830, 2 950 and 6 100, respectively in NEPZ, NWPZ and CZ respectively during 2005–06 crop season and Rs 2 730, 7 605 and 8 355 during 2006–07 crop season, respectively. The range of cost : benefit ratio was from 2.4 to 9.1 during 2 crop seasons in 3 agro-climatic zones in India (Table 4).

Bhanot and Verma (1990) treated the seeds with aldrin and recorded reduced termite damage and increased grain yield (13–30%) in Haryana. Foliar fungicides have little effect on malt quality although it may increase kernel plumpness (Basson and Greeff 1990). Spraying wheat with fungicides can protect a susceptible crop if the potential yield justified the cost of application (Bailey *et al.* 2000). Fungicide application increases yield, 1000-kernel weight, and kernel plumpness in susceptible barley cultivars (Bailey *et al.* 2000). It is thus concluded that the seed treatment with Vitavax power @ 3 g/kg and imidacloprid (Confidor®200SL) @ 0.6 g a i/kg + foliar sprays of propiconazole (Tilt® 25 EC) @ 0.1% and imidacloprid (Confidor® 200SL) @ 20 g ai/ha reduced the incidence of rusts, covered smut, foliar blight, foliar aphids and termites as well as increased the grain yield and test weight significantly over untreated check in barley and may be used in integrated pest management to get maximum net profit/ha.

SUMMARY

Multi-location trials on integrated management of diseases and insect pests of popular variety ‘DWR 28’ malt barley and feed barley variety, ‘Jyoti’ were conducted during 2 consecutive crop season, 2005–06 and 2006–07 at Ludhiana, Karnal, Hisar, Faizabad and Dharwad. The treatments given include, application of higher dose of K fertilizer, soil application of Phorate @ 10 kg/ha at sowing, seed treatment with Vitavax power @ 3.0 g/kg and imidacloprid (Gaucho) @ 0.6 g a i/kg, spores of *Trichoderma harzianum* (isol. DWRLB 1) @ 5 g/kg of seed, foliar sprays of propiconazole (Tilt 25 EC) @ 0.1%, imidacloprid (Confidor) @ 20 g a i/ha

and spore suspension of *T. harzianum* @ 10⁴ spores/ml and Econeem 10 000 ppm @ 0.3%. The treatments were given singly as well as in combination with each other. All the treatments reduced the incidence of stripe and stem rusts, foliar aphids, termites, leaf blight as well as gave higher 1000-grain weight and grain yield over untreated control. Amongst treatments, seed treatment with Vitavax power and imidacloprid + foliar sprays of propiconazole and imidacloprid gave significantly higher yield as well as resulted lower incidence of diseases and insect pests as compared to untreated control. The treatment also resulted a mean gain in the range of Rs 1 830–8 355/ha over untreated control in 3 zones during 2 crop seasons.

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