

# Integrated Pest Management in Basmati Rice

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**R**ice is staple food crop that supports the livelihoods of millions of farmers worldwide. India is the second-largest producer and the first-largest exporter of rice in the world. Indo Gangetic plains in North India is the major basmati rice-producing pocket. The yield potential of rice is severely hampered by many biotic stresses, especially by insect-pests and diseases, for management of these biotic stresses farmers' resort to chemical pesticides. Basmati being an export commodity is always under pressure from European Union and USA, due to indiscriminate pesticide application and accumulation of pesticide residue. Many a times export consignment has been rejected, therefore, to reduce pesticide load and meeting the Maximum Residue Limit (MRL) parameters for export purpose, there is a need to bring the maximum area of Basmati rice under integrated pest management (IPM). ICAR-NRIIPM has validated IPM module at village level in Taraori Basmati rice in Panipat Haryana, Pusa Basmati-1121 in Bambawad, Uttar Pradesh and Dehradoon Basmati in parts of Uttarakhand. Due to the implementation of IPM, farmers are fetching additional premium price of their produce over and above market price, farmers from Rohtak (Haryana) district approached ICAR-NRIIPM for understanding the IPM technology and requested for its validation and implementation in their area in farmers' participatory mode.



Survey conducted in Rohtak district of Haryana indicated that the area which was earlier occupied by the cotton crop has been shifted to rice because of the severe pest problems in cotton and availability of canal water for irrigation. Farmers are growing Pusa basmati 1121, Pusa basmati 1718 and Pusa basmati 1509. Bakane, blast, Bacterial Leaf Blight (BLB), Sheath Blight, yellow stem borer, Brown Plant Hopper, leaf folders are the important pest problems in the area. Farmers were totally dependent upon the advice of pesticides dealer and usually go for 4-6 sprays of different pesticides including tank mix of multiple pesticides.

Therefore, considering the problems and interest of rice farmers and the large area under basmati rice (>30000 ha) in Rohtak district, the project was initiated to validate and promote IPM module in farmers' participatory mode in village Nidana (28°57'13.5"N, 76°29'14.1"E), Rohtak district of Haryana during year 2020. The baseline information collected from the village revealed that the village has about 1000 ha cultivated land with 100% irrigation (Canal 50%; Tube well 50%) facility. About 800 ha is under rice, with >90% of the area under *basmati* rice. Pusa Basmati 1718, PB 1121, and PB 1509 are the main varieties grown in the area. Pusa Basmati 1718 was grown in >50% of the area in the village, whereas Pusa Basmati 1121 and PB 1509 occupied <40% and <10% of the area, respectively. Key pest problems faced by the farmers included Bakane (*Fusarium moniliforme*), blast (*Magnaporthe grisea*), bacterial leaf blight (*Xanthomonas oryzae pv. oryzae*), sheath blight (*Rhizoctonia solani*), brown plant hopper (*Nilaparvata lugens*), yellow stem borer (*Scirpophaga incertulas*), and leaf folder (*Cnaphalocrosis medinalis*). Farmers were fully (100%) dependent on pesticide dealers and company representatives for plant protection advisories. Knowledge about IPM, pest identification, and natural enemies was lacking. A calendar-based blanket application of pesticides was the scheduled activity in the village, which included granular application of chlorantraniliprole, spray of Pymetrozine, tricyclazole, tebuconazole + trifloxystrobin, chloropyrifos, lambda cyhalothrin, and acephate. High doses of nitrogenous fertilizers (urea 450 kg/ha), no green manuring, no seedling treatment; neglecting pest monitoring, and resorting to 3–5 sprays of tank mix of chemical pesticides. The expenditure on control of insect pests and diseases was >Rs 12,500/ha. The average paddy yield was about 40-45 q/ha. Planting of 1 seedling per spot with 35 to 40 days old nursery was the common farming practice followed in the village.



## IPM strategy

Based on the baseline information and pest problems, IPM strategy was formulated. IPM strategy consisted of (i) green manuring with *Sesbania* or mung bean, (ii) soaking of seeds in 2% salt solution (NaCl) to discard unhealthy seeds, (iii) seed treatment with *Trichoderma harzianum* ( $1 \times 10^8$  cfu/g) @ 10g /kg seed for bakane and sheath blight management, (iv) seedling root dip in *Pseudomonas fluorescens* ( $3.0 \times 10^{10}$  cfu/ml) solution @ 5ml/l of water for 30 minutes against bakane, (v) installation of pheromone traps @ 5/ha for YSB monitoring, (vi) placement of straw bundles for spider conservation after 15 days of rice transplanting @ 20 bundles/ha, (vii) One release of egg parasitoid, *Trichogramma japonicum* @ 1, 50, 000/ha after appearance of moths or egg masses of YSB in paddy fields in the month of September, (viii) Manual and chemical weed management, and (ix) Need-based application of chemical pesticides against insect pests and diseases based on economic threshold level (ETL). The paddy straw bundles were first placed in the sorghum field for 15 days for charging with spiders. Subsequently, in rice fields, these bundles were fixed vertically with bamboo sticks so that the lower portion of the bundle remained 15 cm above the water level.



**Implementation of IPM strategy:** The IPM programme was initiated in 2020 with participation of 10 farmers in 20 ha *basmati* rice (PB1718) area in the village Nidana ( $28^{\circ}57'13.5''N$   $76^{\circ}29'14.1''E$ ) of district Rohtak, Haryana. The area coverage under IPM was increased gradually in the consecutive years, *i.e.* making it 100 ha in 2021, 120 ha in 2022 and 200 ha in 2023. The increase in area could be attributed to the success of IPM and an increased awareness about benefits of IPM technology and self-mobilization of a greater number of farmers (48) to adopt IPM technology. Farmers' field schools were organized at regular interval to educate and convince the farmers about the adverse effects of pesticides and pesticide residue problems in export consignment of *basmati* rice, and benefit of IPM in managing pest problems with minimum use of pesticides. Farmers were trained about identification of pests and natural enemies, economic threshold levels of different pests, good agriculture practices, installation of pheromone traps for pest monitoring and straw bundles for spider conservation, spray of? *Pseudomonas fluorescens* at regular intervals in the fields. Critical IPM inputs such as *Trichoderma harzianum*, *Trichogramma japonicum*, pheromone traps for YSB and neem azadirachtin 1500 ppm were provided to the farmers from the institute.

**Refinement of IPM strategy:** Based on the response of the farmers during first two years and keeping in mind the availability of critical IPM inputs to make IPM strategy suitable for adoption

in long run by the farmers in the village, the IPM strategy was refined by excluding a couple of interventions such as straw bundle and *Trichocard* and retaining only simple adoptable IPM interventions as per local conditions. The refined IPM strategy thus consisted of soaking of seeds in 2% salt solution (NaCl) to discard unhealthy seeds, seed treatment with *Trichoderma harzianum* 10g/kg seed, green manuring of main field, seedling root dip treatment with *Pseudomonas fluorescens*, balanced plant nutrition and water management, installation of pheromone traps for YSB monitoring @5/ha, regular field monitoring at weekly intervals, application of neem-based pesticides (Azadirachtin 1500 ppm @5ml/litre water) at low level of pest infestation, application of safer chemical pesticides based on economic threshold level (ETL), hand weeding and need based use of weedicides. The refined IPM strategy was further validated and promoted on large scale.

## Impact of IPM

**Reduction in pest infestation:** The IPM successfully reduced bakane incidence in IPM over FP was 91.79%, 37.14%, 93.19%, and 88.42% during 2020, 2021, 2022, and 2023, respectively. The incidence of BLB was 75.86%, 37.14%, 93.29%, and 88.42% lower in IPM compared to FP. Blast incidence was negligible in 2020, whereas during 2021 to 2023, it was reduced by 37.14%, 88.64%, and 65.45% over FP. The reduction in seasonal mean infestation of yellow stem borer (YSB) by 27%, 31%, 28%, and 7.5% during the mentioned years (Table 1) The leaf folder population remained below the economic threshold level (ETL) throughout the study except in 2023, where it crossed the ETL during the 37-38 SMW, with a peak population of 33.6% in IPM and 43% in FP. This was managed by one application of recommended insecticide. Brown plant hopper was remained below ETL. IPM module proved effective in managing pest problems.

IPM implementation resulted in a significant reduction (average of 4 years) in the number of pesticide applications by >48% and the amount of active ingredients was reduced by >82% over FP fields (2.5 in IPM and 4.88 in FP). The reduction in pesticide use in FP was attributed to increased awareness among farmers about new insecticide molecules used at lower doses. The population of predatory spiders was significantly higher in IPM (0.95-3.85 per hill) compared to FP (0.22-0.54per hill) throughout the study during most of the SMW (Fig. 2), due to the judicious use of safer pesticides.



IPM implementation resulted in an 8.48% increase in yield, >15.60% reduction in input costs, and 29.51% increase in net return compared to FP. The benefit-cost ratio (BCR) in IPM was 2.8, whereas in FP it was 2.17 (Table 2). Farmer field schools and meetings organized at regular interval in the village helped in developing strong linkages among farmers, scientists and extension workers. Mobile numbers of the farmers, scientist/extension scientist from ICAR-IARI and ICAR-NRIIPM were shared among themselves and through Whatsapp group. This facilitated easy communication between farmers and scientists and increased confidence of the farmers. Farmer field schools and meetings organized at regular interval in the village enabled the IPM farmers to identify the major pests and natural enemies (spiders), and understand the role of monitoring, seed treatment, seedling root dip treatment, field sanitation and weed removal, concept of ETL and need based application of safer pesticides in pest management. The study concluded that the wide area validation of IPM strategy in *Basmati* rice proved ecologically safe, economically viable and adoptable under farmers' field conditions.



Table 1: Scenario of pests and natural enemies in rice IPM and FP fields at Nidana, Rohtak, Haryana during *kharif* 2020 to 2023

Years	Treatments variables	YSB (%)	LF (%)	BPH (No./hill)	Bakane (%)	BLB (%)	Blast (%)	Spider (No./hill)
2020	IPM	1.81±1.10	4.99±1.15	00	0.38±0.48	1.05±0.05	00	3.85±0.18
	FP	2.48±0.15	6.63±0.15	00	4.63±0.15	4.35±0.10	00	0.54±0.19
	% Difference in IPM over FP	-27.02	-24.74	00	-91.79	-75.86	00	612.96
2021	IPM	1.45±0.44	5.17±3.09	1.14±1.73	0.83±0.47	0.51±0.55	1.35±1.90	0.95±0.19
	FP	2.13±0.66	2.62±1.61	2.37±2.56	1.31±0.61	0.81±0.81	2.15±2.61	0.19±0.18
	% Difference in IPM over FP	-31.98	97.21	-51.95	-37.14	-37.14	-37.14	392.00
2022	IPM	0.52±0.38	2.62±1.76	0.83±1.39	0.10±0.16	0.06±0.12	0.10±0.22	1.18±0.37
	FP	0.73±0.61	2.08±1.35	1.52±2.02	1.49±0.88	0.68±0.66	0.88±1.35	0.22±0.22
	% Difference in IPM over FP	-28.77	25.96	-45.39	-93.29	-91.18	-88.64	436.36
2023	IPM	2.54±2.13	5.52±9.02	0.62±0.99	0.11±0.15	0.58±1.22	0.19±0.38	1.23±0.33
	FP	2.74±3.61	5.80±11.70	1.41±1.89	0.95±0.76	2.16±4.01	0.55±0.65	0.36±0.20
	% Difference in IPM over FP	-7.30	-4.83	-56.03	-88.42	-73.15	-65.45	241.67

#Values are the mean of 13 weeks ±standard deviation; YSB: Yellow stem borer, LF: Leaf folder, BPH: Brown plant hopper, BLB: Bacterial Leaf Blight; SMW: Standard Meteorological Week

Table 2: Effect of IPM on reduction of chemical pesticides applications, yield and economics in basmati rice fields

Year	Treatments	Number of chemical pesticides Applications	Amount of active ingredient (g ai/ha)	Yield (q/ha)	Cost (₹/ha)	Gross Income (₹/ha)	Net income (₹/ha)	B-C Ratio
2020	IPM	2	222.75	35.5	53185	88750	35565	1.67
	FP	5	1665.25	33.7	64760	84250	19490	1.31
	Difference (%) in IPM over FP	-60	-86.67	5.34	-17.8	5.34	133	
2021	IPM	3	252.00	38.00	55344	133000	77656	2.40
	FP	5	1250.00	34.70	67998	121450	53452	1.79
	Difference (%) over FP	-50	-79.84	9.51	-18.6	9.51	63.99	
2022	IPM	2.00	142	47.50	58735	199500	140765	3.4
	FP	4.50	1139	43.50	66810	182700	115890	2.7
	Difference (%) in IPM over FP	-55.56	-87.5	9.20	-12.1	9.20	21.50	
2023	IPM	3.00	216.75	46.50	54470	199950	145480	3.67
	FP	5.00	653.25	42.50	63146	182750	119604	2.89
	Difference (%) in IPM over FP	-40	-66.82	9.40	-13.8	9.4	20.68	
Pooled (4 years)	IPM	2.5	208	41.9	55433	155300	99866	2.80
	FP	4.88	1177	38.6	65678	142787	77109	2.17
	Difference (%) in IPM over FP	-48.72	-82.29	8.48	-5.60	8.76	29.51	

IPM: Integrated Pest Management; FP: Farmers practices, Market rate (₹/q) of paddy was ₹ 2500, ₹3500, ₹4200 and ₹4300 in 2020, 2021, 2022 and 2023 respectively. Total cost included labor cost for land preparation, nursery sowing, puddling, transplanting, fertilizer application, hand weeding, pesticide application, etc. and material cost such as seed, fertilizer, pesticides, biocontrol agents, and irrigation.