Journal of Integrated Pest Management

ISSUES

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Evaluation of Integrated Pest and Disease Management Module for Shallots in Tamil Nadu, India: a Farmer's Participatory Approach

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J. Integ. Pest Mngmt. 4(2): 2013; DOI: http://dx.doi.org/10.1603/IPM12019

ABSTRACT. Efforts made to evaluate the Integrated Pest Management (IPM) module for shallots through Farmer's Participatory Approach in Tamil Nadu, India, are discussed. The shallot IPM module with special emphasis on nonchemical management components viz., healthy seed bulb selection, seed treatment with bio-pesticides, soil application of bio-pesticides and bio-inputs, growing of barrier crops, installation of sticky traps and pheromone traps, spray application of bio-pesticides, and need-based application of synthetic pesticides were evaluated in large fields in farmers' holdings in six locations during 2009–2012. In all the locations, the IPM fields registered reduced incidence of the major insect pests and diseases viz. onion thrips (*Thrips tabaci* L.) (5.99 thrips/plant), leafminer (*Liriomyza* sp.) (12.59% damage), tobacco cutworm (*Spodoptera litura* F.) (3.51% damage), basal rot (*Fusarium oxysporum* f. sp. *cepae* W. C. Snyder and H. N. Hansen) (3.50% incidence) and purple blotch (*Alternaria porri* (Ellis) Cif.) (24.50 Percent Disease Index) compared with farmer's approach registering higher incidence of onion thrips (11.58 thrips/plant), leafminer (19.65% damage), tobacco cutworm (6.22% damage), basal rot (8.14% incidence), and purple blotch (51.6 Percent Disease Index). The IPM fields registered a higher mean bulb yield of 13.81 t/ha with a cost:benefit ratio of 1:3.05 compared with 10.69 t/ha with a cost:benefit ratio of 1:2.47 in farmer's approach. Field days, exhibitions, and demonstrations were organized in all the locations to popularize the shallot IPM module among the growers.

Key Words: shallot, shallot pests, shallot diseases, onion, onion pests

Onion, *Allium cepa* L. (Alliaceae) is one of the most important commercial vegetable crops in India, cultivated in an area of 756,000 ha. Two main types of onions, bulb onion (*Allium cepa* variety *cepa*) and shallot or multiplier onion (*Allium cepa* variety *aggregatum*), are cultivated in India with the production and productivity of 12.16 million tonnes and 16.10 tonnes/ha, respectively (www.nhb.gov.in). In the state of Tamil Nadu, the southernmost part of India, onion is cultivated in an area of 30,255 ha with a production of 286,000 tonnes. The shallot is the most common type of onion cultivated in Tamil Nadu and it is commonly propagated through bulbs. The average productivity of onion in Tamil Nadu is 9.45 tonnes/ha (www.tn.gov.in). Insect pests, especially onion thrips (*Thrips tabaci* L.) (Fig. 1), leafminer (*Liriomyza* sp.) (Fig. 2), tobacco cutworm (*Spodoptera litura* F.) (Fig. 3), and diseases, especially purple blotch (*Alternaria porri* (Ellis) Cif.) (Fig. 4) and basal rot (*Fusarium oxysporum* f. sp. *cepae* W. C. Snyder and H. N. Hansen) (Fig. 5), limit the production and productivity of onion in the state. *T. tabaci* is considered a pest of national importance in India, causing an annual yield loss of 10–15% in onion through feeding damage (Fig. 6) and indirectly through predisposing onion plants to purple blotch (Fig. 7) and transmitting Iris Yellow Spot Virus (IYSV) disease (Gupta et al. 1994, Zen et al. 2008). Repeated application of insecticides has resulted in resistance development in onion thrips to insecticides (Alston and Drost 2008). Leafminers have become serious pests on *Allium* sp. in many parts of the world, causing economic damage to onion and other vegetables (Chen et al. 2003). Leafminer problems are exacerbated by use of synthetic pesticides that kill natural enemies (Arida et al. 2002b). Yellow sticky traps have been reported to be effective in trapping onion thrips (Cho et al. 1995, Demirel and Cranshaw 2005) and leafminer adults (Tryon et al. 1980, Unmole et al. 1999). Tobacco cutworm, a polyphagous pest, causes severe defoliation in onion (Atwal and Dhaliwal 2005). Neem extracts and neem oil have been found to be effective in checking onion pests (Sonata et al. 2005, Sharma and Seth 2005, Mishra et al. 2007, Krishna Kumar et al. 2008).

Basal rot is an economically important disease of onion and generally occurs when soil temperatures are very warm (optimum 29°C). Disease incidence increases where onion is grown continuously. The early symptoms in the field are yellowing of leaves and tip dieback. As the disease progresses, the whole plant may collapse and, if the plant is pulled, it often comes out without any roots attached because they have decayed. If infection occurs late in the season, the symptoms may not show up until the onions are in storage because of latent infections (Brayford 1996). Yield losses of 25–35% to *Fusarium* basal rot have been reported in onion (Lacy and Roberts 1982). Purple blotch of onion is a problem particularly during cooler months as the disease spreads rapidly under favorable climatic conditions causing serious yield losses (Gupta et al. 1981). The humid climate with temperatures ranging from 18 to 30°C and relative humidity of 80–90% favors the disease development. Small brown spots with purplish centers are characteristic of this disease. Under favorable conditions, the spots form into oval lesions that have a purplish tint with concentric rings. The lesions may girdle leaves/stalk and cause drying. The infected plants fail to develop bulbs. Older leaves are more susceptible to the disease. The loss in yield resulting from this disease is around 20–25% and the severity of purple blotch in onion is always higher in fields with

Fig. 1. Onion thrips injury to shallot leaves.

Fig. 2. Leafminer injury in shallot leaf.

Fig. 3. Tobacco cutworm damage in shallot.

onion thrips (Thind and Jhooty 1982, Yasodha and Natarajan 2008).

Onion growers in the state generally rely on synthetic pesticides like profenophos, acephate, imidacloprid, fipronil, chlorpyrifos, cypermethrin + chlorpyrifos, mancozeb, carbendazim, carbendazim + mancozeb, wettable sulfur, and so forth, for management of pests and diseases and the frequency of applications ranges from six to nine sprays depending upon the season and pests and

Fig. 4. Lesion in shallot leaf caused by purple blotch.

Fig. 5. Symptom of basal rot infection in shallot.

Fig. 6. Onion thrips infested shallot field presenting burnt up appearance.

diseases load (Selvamuthukumar 2011). Repeated synthetic pesticides applications often result in resistance development, resurgence, and natural enemy destruction besides environmental degradation (Dent and Walton 1997, Thanki et al. 2003). One of the challenges of developing and implementing an IPM module is to successfully balance the goals of reducing pesticide use while maintaining the crop quality demanded by the farmer and the market. In response to the threat of severe damage and economic loss by pests and diseases in shallot, the U.S. Agency for International Development (USAID) funded project IPM–CRSP (Integrated Pest Management– Collaborative Research Support Program), in which Tamil Nadu Agricultural University (TNAU), India is a collaborator, has developed an integrated pest manage-

Fig. 7. Combined infection of purple blotch and onion thrips.

Fig. 8. Women farmers engaged in selection of disease free seed bulbs for planting.

ment (IPM) module for shallot (Gajendran et al. 2011). The IPM module is bio-intensive with emphasis on nonchemical components. The shallot IPM module was test verified in farmers' holdings in large fields in six locations from 2009 to 2012 and compared with farmers' practice, where total reliance on synthetic insecticides (six to nine sprays in different locations) was observed in major onion growing tracts of Tamil Nadu.

Study Methods and Approach

Implementation of IPM Module. Six locations in the state of Tamil Nadu in southern India, where shallot is the major crop were selected for the program and the IPM module was evaluated in *Kharif* (June to September) and *Rabi* (October to February) seasons.

Location 1: Irur, Perambalur District (*Rabi* 2009–2010)
Location 2: Ayyalur, Dindigul District (*Kharif* 2010)
Location 3: Alathur, Perambalur district (*Kharif* 2010)
Location 4: Sengattupatti, Trichy District (*Rabi* 2010–2011)
Location 5: Sathiramanai, Perambalur District (*Rabi* 2010–2011)
Location 6: Narasingapuram, Trichy District (*Rabi* 2011–2012)

At each location, evaluation of the IPM module was carried out in area of 0.4 ha and compared with farmer's practice in an area of 0.4 ha. The commonly grown shallot cultivar of the region Co 4 was used in all the locations.

The IPM–CRSP program working with Tamil Nadu Agricultural University (TNAU) has developed IPM module to solve pest and disease problems in shallot with emphasis on bio-pesticides and behavioral approaches. The IPM–CRSP-TNAU program has strongly promoted the transfer of shallot IPM module to growers by aggressive technology transfer programs. The details of IPM module and technology transfer activities are discussed. Selection of experimental fields in onion growing regions was made with the assistance of extension officials of the State Department of Agriculture/ Horticulture in the respective areas. The details of IPM module are discussed below.

Bulb Selection and Treatment. Selection of healthy bulbs for planting (Fig. 8) is important as the basal rot caused by *Fusarium* sp. is both a field and storage fungus (Coskuntuna and Ozer 2008). Basal rot incidence is one of the major causes for poor field stand as it causes rotting of the plant in the early stage of the crop growth. Healthy (disease free) seed bulbs were manually selected from stored seed onion before planting.

Pseudomonas fluorescens and *Trichoderma viride* have proven to be effective bio-control agents against basal rot pathogen (Malathi and Mohan 2011). These antagonistic organisms induce systemic resistance in plants and in addition promote plant growth (Rajendran and Ranganathan 1996, Bennett and Whipps 2008, Bennett et al. 2009). Onion bulb treatment with *P. fluorescens* (Pf1 TNAU formulation) (5 g/kg) + *T. viride* (TNAU formulation) (5 g/kg) in 20 ml of water/kg of seed bulbs was applied before planting. The bio-suspension was sprinkled over the seed bulbs and manually turned for uniform coating of the bio-pesticides over the seed bulbs.

Soil Amendments With Bio-Products. Field application of bio-pesticides reduces soil-borne pathogens like *Fusarium* and promotes buildup of antagonistic organisms and promotes plant growth (Champawat and Sharma 2003, Altintas and Bal 2008, Coskuntuna and Ozer 2008). Application of bio-fertilizers and Arbuscular Mycorrhizal Fungus (AMF) promotes plant growth and confers resistance to biotic stress (Srivastava and Tiwari 2003). AMF has been shown to increase resistance to root-infecting pathogenic fungi like *Fusarium* spp. and root invading nematodes (Lindermann 1994). Neem cake application has been effective in checking pests and disease besides promoting plant growth (Rukmani and Mariappan 1990, Chakrabarti and Sen 1991). Considering the beneficial aspects of the bio-inputs, the following bio-inputs viz. *P. fluorescens* (TNAU formulation) (1.25 kg/ha), *T. viride* (TNAU formulation) (1.25 kg/ha), Azophos (TNAU formulation of Azospirillum + Phosphobacteria) (4 kg/ha), AMF (TNAU formulation) (12.5 kg/ha), and Neem cake (commercial grade neem seed oil cake) (250 kg/ha) were thoroughly mixed and applied uniformly in the field before planting (Fig. 9).

Maize as Barrier Crop. Growing maize as a barrier crop has been effective in preventing the entry of onion thrips to onion fields and in the conservation of coccinellid populations (Srinivas and Lawande 2002). In the current study, TNAU maize hybrid Co H (M) 5 was sown closely in two rows all along the field border at the time of shallot planting.

Pheromone and Sticky Traps. Sex pheromone traps are useful tools for monitoring, mass trapping, and timing of insecticidal application in the management of cutworms, *Spodoptera* spp. in onion (Arida et al. 2002a). Sleeve type pheromone traps (supplied by M/s Grenicon Agrotech Private Ltd., Chennai, India) baited with pheromone lure of

Fig. 9. Mixing of bio-inputs for soil application before planting.

S. litura were installed in the IPM fields at 12/ha and the lures were replaced every 2 wk. Yellow sticky traps (Highway yellow shade polyethylene film of 30 cm height and 90 cm length smeared with clear castor oil) were installed at 12/ha just above the crop canopy using wooden poles at both ends (Fig. 10). The oil was changed each week to ensure adequate trapping.

Foliar Application of Bio-Pesticides. Normally onion thrips infest shallots 4 wk after planting. A foliar spray of *P. fluorescens* (5 g/lit) and *Beauveria bassiana* (10 g/lit) was applied on 30th day of planting for the management of onion thrips in the early stage. *B. bassiana* alone and in combination with other bio-pesticides has been reported to be effective against onion thrips (Thungrabeab et al. 2006, Almazraawi et al. 2009). A commercial formulation of neem containing 1% (10,000 ppm) azadirachtin was sprayed at 2 ml/liter on 40th day after planting for the management of insect pests.

Foliar Application of Synthetic Pesticides. Synthetic pesticide application was carried out in IPM fields only on need basis and insecticides (profenophos 50 EC [2 ml/liter], triazophos 50 EC [2 ml/liter], and dimethoate 30 EC [(2 ml/liter]) were sprayed for the management of onion thrips, leafminer, and cutworms. These synthetic insecticides were applied when onion thrips population, leafminer, and tobacco cutworm damage crossed 10 thrips/plant, 10% leaf damage, and 5% infested plants, respectively. For the management of purple blotch disease, spray application of tebuconazole 250 EC (1.5 ml/liter) or mancozeb 75 WP (2.0 g/liter) was made after the initial appearance of the disease as it spreads quickly and causes severe damage within a short period.

Sampling and Observations. Five microplots of 20 m^2 were chosen in each treatment for recording observations on pests and diseases in all the six locations. In each microplot, onion thrips population was counted from 10 randomly selected plants. Leafminer damage was assessed by counting total number of leaves and infested leaves from 10 randomly selected plants. Tobacco cutworm damage was assessed by counting the total number of plants in each microplot and damaged plants. Incidence of basal rot was assessed by counting the total number of plants in each microplot and infected plants and expressed as percent incidence. Purple blotch incidence was assessed from 10 randomly selected plants in each microplot by following a 0–9 rating scale and the severity was expressed as Percent Disease Index (PDI).

Farmer's Approach Comparison

The shallot growers in the project area generally used synthetic insecticides and fungicides for pest and disease management. The number of sprays with synthetic pesticides in farmer's practice ranged from 6 to 9 in different locations depending upon the severity of pests and diseases in different seasons. None of the farmers in the experimental location adopted healthy bulb selection, bulb treatment, bio-pesticide/bio-fertilizer application, sticky trap, and pheromone trap installation.

Fig. 10. Installation of yellow sticky traps in shallot field.

General agronomic practices like plowing, planting, manuring, irrigation, weeding, and so forth, were carried out as per the recommendations of the Crop Production Techniques of Horticultural Crops 2004 in both IPM and farmers' approach fields (Anonymous 2004). The expenditure incurred in raising barrier crop of maize and the income realized through maize was taken into account in calculating cost benefit ratio of IPM fields.

Data Analysis. The experimental data were subjected to analysis of variance (ANOVA) for determining the level of significance (Gomez and Gomez 1984). In each location, the microplots served as replicates for each treatment and observations in each location were compared statistically by paired *t*-test. The mean values of pest and disease incidence, bulb yield and economics of each location were treated as replicates and the overall mean of six locations were compared statistically by ANNOVA.

Major Findings

Pests and Diseases

Location I. Irur, Perambalur District (*Rabi 2009–2010*). The results revealed that the IPM field registered minimum population of onion thrips (10.81 ± 0.49 thrips/plant), reduced leaf injury by leafminer (13.20 ± 0.60% damage) and tobacco cutworm (5.48 ± 0.31% damage) compared with a higher thrips population (14.85 ± 0.60 thrips/plant), leafminer (23.61 ± 1.05% damage), and tobacco cutworm (9.13 ± 0.68% damage) infestation in farmer's practice. Incidence of basal rot was found to be lower in IPM fields (1.8 ± 0.34%) as compared with 5.6 ± 0.40% incidence in farmer's practice. Occurrence of purple blotch was noticed in both the fields and the severity was expressed in PDI and it was lesser (20.0 ± 1.13 PDI) in IPM field when compared with farmer's approach which recorded a disease severity of 45.6 ± 1.59 PDI (Table 1).

Location II. Ayyalur, Dindigul District (*Kharif 2010*). Onion thrips, tobacco cutworm, and basal rot alone were noticed in the experimental fields and all these pests and diseases were registered at reduced level in IPM field than in farmer's approach. The percent reduction of onion thrips population, tobacco cutworm damage, and basal rot incidence in IPM field over farmer's approach was 65.7, 39.4, and 52.0, respectively (Table 1).

Location III. Alathur, Perambalur District (*Kharif 2010*). The mean onion thrips population in IPM field was 4.85 ± 0.37/plant compared with 10.22 ± 0.48/plant in farmer's approach and the basal rot incidence was lesser in IPM field (4.80 ± 0.60%) as compared with 12.30 ± 0.92% in farmer's approach. Incidence of purple blotch, tobacco cutworm, and leafminer was not observed in the experimental fields during the season (Table 1).

Location IV. Sengattupatti, Tiruchirappalli District (*Rabi 2010–11*). The mean onion thrips population in IPM field was 8.30 ± 0.44/plant compared with 15.95 ± 0.98/plant in farmer's approach. Leafminer infestation was observed to an extent of 13.76 ± 0.53% damage in IPM field compared with 19.80 ± 0.86% in farmer's approach. Cutworm damage was 3.92 ± 0.35% in IPM field and it was 6.85 ± 0.57% in farmer's approach. Incidence of basal rot was noticed to an extent of 2.29 ± 0.47% in IPM field as against 5.04 ± 0.67% in farmer's approach. The severity of purple blotch was 24.4 ± 1.68 PDI in IPM field as against 46.7 ± 1.15 PDI in farmer's approach (Table 1).

Location V. Sathiramanai, Perambalur District (*Rabi 2010–11*). Adoption of IPM module registered lesser mean onion thrips population (1.71 ± 0.31 thrips/plant), leafminer injury (13.57 ± 0.67% damage) and cutworm injury (4.83 ± 0.54% damage) compared with farmer's approach with 4.33 ± 0.43 thrips/plant, 18.88 ± 0.93% leafminer injury, and 7.35 ± 0.54% cutworm damage. The incidence of basal rot was lesser in IPM field with 1.71 ± 0.32% as compared with 4.33 ± 0.48% in farmer's approach. The severity of purple blotch in IPM field was 31.1 ± 0.82 PDI as against 57.8 ± 1.07 PDI in farmer's approach (Table 1).

Table 1. Evaluation of Shallot IPM module through farmer's participatory approach

Treatment	Thrips population (no./plant)	Leafminer damage (%)	Tobacco cutworm damage (%)	Basal rot incidence (%)	Purple blotch (PDI)
Location I (*Rabi* 2009–2010)					
IPM field	10.81 ± 0.49	13.20 ± 0.60	5.48 ± 0.31	1.80 ± 0.34	20.0 ± 1.13
Farmer's approach	14.85 ± 0.60	23.61 ± 1.05	9.13 ± 0.68	5.60 ± 0.40	45.6 ± 1.59
Percent decrease over farmer's approach	27.2	44.1	40.0	67.9	56.1
Location II (*Kharif* 2010)					
IPM field	3.36 ± 0.27	—	0.97 ± 0.18	7.25 ± 0.91	—
Farmer's approach	9.80 ± 0.53	—	1.60 ± 0.19	15.10 ± 1.28	—
Percent decrease over farmer's approach	65.7		39.4	52.0	
Location III (*Kharif* 2010)					
IPM field	4.85 ± 0.37	—	—	4.80 ± 0.60	—
Farmer's approach	10.22 ± 0.48	—	—	12.30 ± 0.92	—
Percent decrease over farmer's approach	52.5			61.0	
Location IV (*Rabi* 2010–2011)					
IPM field	8.30 ± 0.44	13.76 ± 0.53	3.92 ± 0.35	2.29 ± 0.47	24.4 ± 1.68
Farmer's approach	15.95 ± 0.98	19.80 ± 0.86	6.85 ± 0.57	5.04 ± 0.67	46.7 ± 1.15
Percent decrease over farmer's approach	48.0	30.5	42.8	54.6	47.8
Location V (*Rabi* 2010–2011)					
IPM field	1.71 ± 0.31	13.57 ± 0.67	4.83 ± 0.54	1.71 ± 0.32	31.1 ± 0.82
Farmer's approach	4.33 ± 0.43	18.88 ± 0.93	7.35 ± 0.54	4.33 ± 0.48	57.8 ± 1.07
Percent decrease over farmer's approach	60.5	28.1	34.3	60.5	46.2
Location VI (*Rabi* 2011–2012)					
IPM field	6.92 ± 0.71	9.83 ± 0.67	2.37 ± 0.28	3.12 ± 0.54	22.4 ± 0.96
Farmer's approach	14.35 ± 0.60	16.29 ± 0.93	6.15 ± 0.48	6.46 ± 0.61	56.1 ± 1.06
Percent decrease over farmer's approach	51.8	39.7	61.5	51.7	60.1
Overall mean					
IPM field	5.99 ± 1.37	12.59 ± 0.93 (20.72)	3.51 ± 0.82 (10.43)	3.50 ± 0.88 (10.91)	24.5 ± 2.39 (30.93)
Farmer's approach	11.58 ± 1.78	19.65 ± 2.20 (26.26)	6.22 ± 1.22 (14.02)	8.14 ± 1.82 (16.61)	51.6 ± 3.15 (45.90)
Percent decrease over farmer's approach	48.3	35.9	43.6	57.0	52.5
S. Ed.	0.81	0.80	0.64	0.63	2.05
C.D. ($P = 0.05$)	2.08	2.55	1.77	1.62	6.51

Figures in parentheses are *arcsine* transformed values.
S. Ed., standard error of difference; C.D., critical difference at 5% level among the values given in parentheses.

Location VI. Narasingapuram, Tiruchirappalli District (*Rabi* 2011–12). At Narasingapuram location, adoption of IPM module reduced the incidence of shallot pests and diseases as in other locations and the percent reduction over farmer's approach ranged from 39.7 to 61.5%. In IPM field, the population of onion thrips and injury by leafminers and cutworms were reduced by 51.8, 39.7, and 61.5%, respectively. Similarly, the severity of basal rot and purple blotch were also reduced statistically by adoption of IPM module, registering 51.7 and 60.1%, respectively (Table 1).

The overall mean of all the six locations also revealed the reduced incidence of the major insect pests and diseases viz. onion thrips (5.99 thrips/plant), leafminer (12.59% damage), tobacco cutworm (3.51% damage), basal rot (3.50% incidence), and purple blotch (24.50 PDI) in IPM field compared with farmer's approach registering higher incidence of onion thrips (11.58 thrips/plant), leafminer (19.65% damage), tobacco cutworm (6.22% damage), basal rot (8.14% incidence), and purple blotch (51.6 PDI) (Fig. 11).

Bulb Yield and Economics. It was evident from the results of all the six locations that the adoption of shallot IPM module significantly enhanced the bulb yield to the tune of 20.2 (location II) to 47.0 (location I) percent over farmer's approach. In location I, IPM field registered significantly higher bulb yield (15.62 ± 0.90 t/ha) than the farmer's approach (12.13 ± 0.84 t/ha). Adoption of IPM module enhanced the shallot bulb yield (12.50 ± 0.46 t/ha) as against farmer's approach (10.40 ± 0.68 t/ha) in location II with a cost benefit ratio of 1:1.73. In location III, higher bulb yield of 13.60 ± 0.77 t/ha was recorded in IPM field that is significantly superior over farmer's approach registering 11.20 ± 0.60 t/ha. The same trend continued in locations IV, V, and VI also registering higher bulb yields of 14.58 ± 0.92 t/ha, 12.90 ± 0.70 t/ha, and 13.64 ± 0.70 t/ha, respectively in IPM fields compared with farmer's approach that recorded significantly reduced yields (Table 2). The cost benefit ratio in all the locations ranged from 1:1.73 (location II) to 1:6.36 (location IV) in IPM fields compared with 1:1.41 (location I) to 1:5.42 (location IV) in farmer's approach (Fig. 12). The wide variation in the cost benefit ratio of IPM field and farmer's approach between seasons is because of high fluctuation in the market price of shallot.

Analysis (ANOVA) of mean values of six locations revealed that the adoption of IPM module in shallot was significantly superior over farmer's practice in reducing the incidence of onion thrips population (5.99 ± 1.37 thrips/plant vs. 11.58 ± 1.78 thrips/plant), leaf-miner (12.59 ± 0.93% damage vs. 19.65 ± 2.20% damage), tobacco cutworm (3.51 ± 0.82% damage vs. 6.22 ± 1.22% damage), basal rot (3.5 ± 0.88% vs. 8.14 ± 1.82%), and purple blotch (24.5 ± 2.39 PDI vs. 51.6 ± 3.15 PDI) (Table 1). The IPM fields registered significantly a higher mean bulb yield of 13.81 ± 0.47 t/ha with a cost benefit ratio of 1:3.05 ± 0.78 compared with 10.69 ± 0.43 t/ha with a cost benefit ratio of 1:2.47 ± 0.68 in farmer's approach (Table 2).

Shallot IPM Module Dissemination

Normally, the onion growers of Tamil Nadu get technical advisory services from the local extension functionaries of the State Department of Agriculture/Horticulture and Krishi Vigyan Kend-

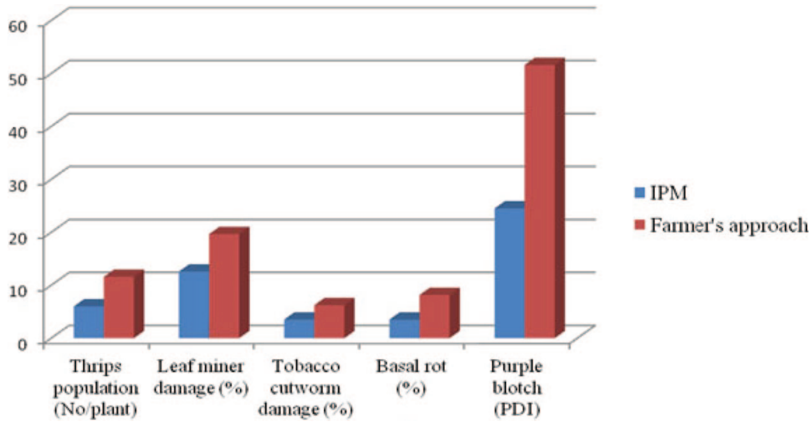

Fig. 11. Impact of shallot IPM Module on pest and disease incidence (mean of six locations).

Table 2. Effect of Shallot IPM module on bulb yield and cost benefit ratio

Treatment	Location I (*Rabi* 2009–2010)	Location II (*Kharif* 2010)	Location III (*Kharif* 2010)	Location IV (*Rabi* 2010–2011)	Location V (*Rabi* 2010–2011)	Location VI (*Rabi* 2011–2012)	Overall mean
Bulb yield (t/ha)							
IPM field	15.62 ± 0.90	12.50 ± 0.46	13.60 ± 0.77	14.58 ± 0.92	12.90 ± 0.70	13.64 ± 0.70	13.81 ± 0.47
Farmer's approach	12.13 ± 0.84	10.40 ± 0.68	11.20 ± 0.60	11.28 ± 0.72	9.87 ± 0.68	9.28 ± 0.62	10.69 ± 0.43
Percent increase over farmer's approach	28.8	20.2	21.4	29.3	30.7	47.0	29.2
S. Ed.							0.33
C.D. ($P = 0.05$)							0.85
Cost benefit ratio							
IPM field	1:1.84	1:1.73	1:1.96	1:6.36	1:4.40	1:1.98	1:3.05 ± 0.78
Farmer's approach	1:1.41	1:1.48	1:1.61	1:5.42	1:3.50	1:1.39	1:2.47 ± 0.68

S. Ed., standard error of difference; C.D., critical difference at 5% level among the values given in parentheses.

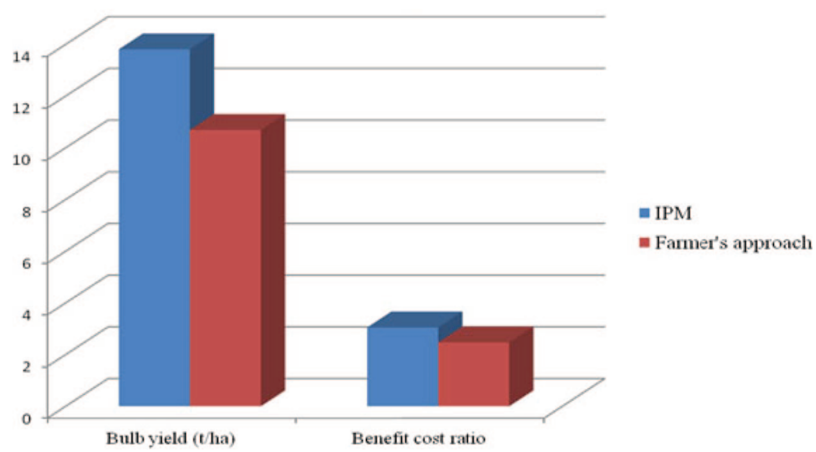

Fig. 12. Impact of shallot IPM Module on bulb yield and economics (mean of six locations).

ras (KVK) (Farm Science Centers) of the State Agricultural University. However, these are inadequate considering the complexity of the pests and diseases problems and expertise available in the extension departments. Hence, the IPM–CRSP team of the TNAU joined hands with the extension officials, KVK and All India Radio (AIM) for speedy dissemination of the IPM module among the shallot growers.

Method demonstrations on seed bulb treatment with bio-pesticides, soil application of bio-inputs and neem cake, installation of yellow sticky traps and pheromone traps in the field were organized in all the locations to disseminate the eco-friendly technologies of shallot IPM to farming community.

In all the six locations, field days and exhibitions were organized at the time of harvesting to popularize bio-intensive IPM module among the shallot growers. Farmers-Scientists interactive session and feed back (sharing of experiences) by the farmers who laid out demonstration trials were also organized.

To popularize the bio-inputs viz., *T. viride*, *P. fluorescens*, pheromone traps and yellow sticky traps among the growers, free distribution of these inputs was made to growers where the demonstration trials were conducted (Figs. 13 and 14). Besides, pamphlets on shallot IPM module was prepared in local language and distributed to growers for dissemination of technology. Dissemination of shallot IPM module through publication in local newspapers, journals were made to popularize the technology among the shallot growers.

A Farm School program on radio was organized under the USAID IPM–CRSP program involving the Directorate of Extension Education, TNAU, and All India Radio, Tiruchirappalli. In total, 1,447 vegetable growers from all over Tamil Nadu state registered and benefited directly. Besides, the broadcast covered

Fig. 13. Distribution of yellow sticky traps to shallot growers during Field Day.

Fig. 14. Distribution of bio-pesticides to shallot growers during Field Day.

Fig. 15. Welcome sign for arriving participants in Tamil Nadu farmer meeting celebrating IPM radio series produced by All India Radio (AIM), Tamil Nadu Agricultural University (TNAU), and the South Asian regional project of the IPM–CRSP.

nearly 70% of the area in Tamil Nadu state, benefitting thousands of onion growers. In January 2012, a large grower meeting was held at the Tiruchirappalli campus of TNAU to celebrate the success of the AIM radio series and the production of a shallot IPM manual, supported by IPM–CRSP at TNAU. Approximately 600 Tamil Nadu farmers attended, and some of the participating farmers gave testimonials on the importance of the extension efforts to their farming (Figs. 15–17). In addition, various TNAU booths further illustrated IPM–CRSP methods, including some created by TNAU undergraduate students (Fig. 18).

Fig. 16. Farmer providing comments on the value of IPM lessons provided over AIR.

Fig. 17. Tamil Nadu farmers gathered for IPM celebration at TNAU–Trichy.

Fig. 18. TNAU undergraduates at diorama illustrating several IPM tools developed by IPM–CRSP in South Asia (pheromone trapping, yellow sticky traps, maize border crops, and soil biopesticides).

Adoption of Shallot IPM Approach. Assessment of impact of shallot IPM module demonstrations and dissemination activities on the production and productivity of shallot in the areas where these activities were carried out revealed that the farmers have realized reduced production cost (2.60%), increased bulb production (19.28%), and higher economic returns (23.89%) over the conventional farmer's approach where the total reliance was on synthetic chemical pesticides. The lack of an IPM strategy in shallot production was overcome through our approach under the IPM–CRSP program and it has been popularized in major shallot growing areas of Tamil Nadu, India. Though some of the progressive farmers adopted the entire package, few major components of the shallot IPM module viz., selection of healthy seed bulbs, bulb treatment with *Pseudomonas fluorescens* and *Trichoderma viride,* soil application of *Pseudomonas* and *Trichoderma* along with neem cake and spray application of azadirachtin are adopted by most of the shallot growers of the region. The other components like growing of maize as border crop and installation of traps are being adopted on a smaller scale. However, efforts are being made to popularize these technologies in shallot growing areas under the IPM–CRSP program.

We conclude that a major constraint in shallot production in Tamil Nadu, India, has been a lack of IPM strategies to replace pesticide-reliant tactics and the failure to adopt the IPM strategies developed. The IPM–CRSP shallot program has been able to overcome both of these constraints by developing a package of IPM module and successfully transferring it to onion farmers. The IPM module for shallot developed by Indian and United States scientists under USAID funded IPM–CRSP project was evaluated through Farmer's Participatory Approach in Tamil Nadu, India. The shallot IPM module evaluated in large fields (farmers' holdings) in six locations during 2009–2012 registered reduced incidence of the major pests and disease, especially onion thrips, leafminer, tobacco cutworm, basal rot, and purple blotch coupled with higher bulb yield and cost benefit ratio compared with farmers' approach. With a view to popularize the shallot IPM module among the shallot growers, IPM Field Days, exhibitions, and method demonstrations were organized in all the locations. Women farmers, who are engaged in shallot cultivation actively participated and interacted with the scientists. Popularization the shallot IPM module was also made through news magazines, All India Radio and technical bulletins.

Acknowledgments

This publication was made possible through support provided by the Agriculture Office within the Bureau for Economic Growth, Agriculture, and Trade (EGAT) of the U.S. Agency for International Development, under the terms of the IPM–CRSP (Award EPP-A-00-04-00016-00). The opinions expressed herein are those of the author and do not necessarily reflect the views of the U.S. Agency for International Development.

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Received 16 September 2012; accepted 6 June 2013.