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Farmers' centred approach for area wide implementation of sustainable IPM technology and economic analysis for onion (*Allium cepa*) during *rabi* season

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ABSTRACT

Field experiment was conducted in onion (*Allium cepa* L.) during 2012-13, 2013-14 and 2014-15 at Singoha-Singohi-Rambha, Karnal, Haryana with a view to study the validation, economic viability and feasibility of adaptable and rational IPM technology in a farmers' driven approach. The IPM technology for onion crop comprised mainly the raising healthy nursery using raised nursery beds, mixing *Trichoderma viride* (c.f.u. 2×10^9) fortified in FYM (@ 50 g/3 sq m), need based spray of urea @ 0.2% or micronutrient mixture to manage yellowing; in main crop -giving adequate irrigation during crop season, and irrigating fields through sprinkler to wash off thrips, spray of spinosad against thrips in March ,i.e. bulb initiation stage at 50 DAT, need based spray of fipronil /profenophos, prophylactic spray with mancozeb and need based spray of mancozeb + carbendazim or propiconazole against *Stemphylium* blight and need based application of sulphur for tip burning due to sulphur deficiency was very effective in reducing the incidence of pests and minimizing the yield losses. The adoption of IPM technology, resulted in reducing the number of chemical sprays to 4-5 from 8-9 in non-IPM fields in a season with higher onion yields of 18.13, 28.62 and 16.0 tonnes/ha in IPM and 16.58, 27.50 and 14.86 tonnes/ha in non-IPM fields and with marginally higher CBR of 1:2.24, 1:4.15 and 1:1.73 in IPM than 1:2.04, 1:3.90 and 1:1.58, respectively in non-IPM. There was a net income increase of ₹ 15434, 12650 and 11 343 /ha in IPM fields over non-IPM.

Key words: *Allium cepa*, IPM, Onion, Participatory approach

Onion (*Allium cepa* L.) is a widely cultivated vegetable crop all over the country, which is also known as `queen of kitchen. Onion is cold-summer season crop, easy to grow because of its hardiness. The crop occupies an area of 1.20 million ha with an annual production of over 19.4 million tonnes and is far behind many countries in terms of productivity which remains very low (16.1) while the world onion production is 85.9 million tonnes with a productivity of 19.3 tonnes/ha (NHB 2015). One of the constraints perceived for its low productivity is the increasing prevalence of insect pests, diseases and nematodes. Though the pest spectrum in onion is not very high. However, pests, viz thrips (*Thrips tabaci* Lindermann) and *Stemphylium* blight (*Stemphylium vesicarium* Wallr.), cause substantial yield losses (Gupta *et al.* 1994). Due to its cultivation during different seasons, i.e. *kharif*, late *kharif* and *rabi* especially in South India and Maharashtra, economic losses due to pests vary during different seasons. In North India, bulb crop is mainly grown during *rabi*-summer season while seed crop season extends from October to May. These two three pests are the major constraints in getting higher onion yields. Quicker control strategy for these pests and quest of getting higher yields, has led to indiscriminate, unnecessary and excessive use of chemical pesticides. It is not unusual for the onion growers to apply 9-10 chemical sprays in a crop season, which is not always necessary to increase appreciable crop yield. In such scenario, green leaves and bulbs of onion are likely to retain unavoidably high level of pesticide residues, which is not only hazardous to consumers but may affect the export quality as well.

Numerous pest management strategies have been developed for onion but these have mostly been dealt in isolation and individually and thus have not met with the desired success. The integration of all the pest management strategies in a farmers' driven mode could reduce application of harmful pesticides to a great extent. Keeping this in view, validation of multifaceted adaptable IPM technology in onion crop was carried out in a participatory manner at farmers' fields to reduce the dependence on chemical pesticides and protecting the ecosystem as a whole.

MATERIALS AND METHODS

Three year trials on validation of IPM technology in *rabi*-summer season onion crop were carried out during 2012-13, 2013-14 and 2014-15 at Singoha-Singohi-Rambha, Karnal district, Haryana (28° 16' N, 77° 05' E). Before initiation of validation of IPM technology, adaptable IPM

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module for onion crop was synthesized based on the base line information collected on the crops, pests, pest status and their management from farmers in Singoha-Singohi-Rambha; recommendations made by State Agricultural University for onion crop pest management and research litreature published by eminent workers on onion pest management. The synthesized IPM module was thus validated during 2012-13, initially in an area of 10 acres comprising 10 farming families with the following interventions: (i) Raised nursery beds (about 10 cm above ground level) for good drainage. (ii) Mix fungal antagonist *Trichoderma viride* (c.f.u. 2 × 109/g) @ 50 g/ 3 sq m through well rotten FYM before sowing. (iii) Need based spray of urea @ 0.2% or micronutrient mixture to manage yellowing after unseasonal rains during January. (iv) Dipping seedlings in *Pseudomonas fluorescence* @ 5 ml/litre for 30 minutes before planting. (v) Giving adequate irrigation during crop season for destruction of hibernating thrips pupae in soil and irrigating fields through sprinkler to wash off thrips. (vi) Installation of blue coloured traps @ 10/acre for thrips. (vii) Spray of spinosad 45 SC @ 75 g a.i./ha against thrips in March, i.e. bulb initiation stage at 50 DAT. (viii) Need based spray of fipronil 5 SC @ 1 ml/litre or acephate 75 WP @ 2 ml/litre or profenophos 50 EC @0.1% for thrips, prophylactic spray with mancozeb 75 WP@ 0.25% and need based spray of mancozeb + carbendazim @0.2% or propiconazole 25 EC @ 0.1% against *Stemphylium* blight. (ix) Need based spray of sulphur 80 WP @ 0.2% for tip burning due to sulphur deficiency.

The results on the pest incidence/natural enemy population and the economic viability of IPM were compared with FP (Farmers' own way of managing the pests) which consisted of only pesticides such as: Captan 80 WP @ 0.2%, Mancozeb 75 WP @ 0.2%, Imidacloprid 17.8 SL (0.4 ml/ ltre), Hexaconazole 5 EC (0.1%), Tricyclozole 75 WP @ 0.1%, Fipronil 5 SC, Metalyxyl 4% + mancozeb 64% @ 0.2%, Propiconazole 25 EC@ 0.1%.

The farmers usually tend to give higher than the recommended dose. Most of the farmers are unable to decide the accurate dose of pesticides, which are recommended by the manufacturers.

During 2013-14, the adaptable IPM technology was refined and revalidated in a larger area of 25 acres comprising 25 farming families. The installation of blue coloured sticky traps meant for thrips trapping was stopped as it attracted large number of syrphid flies which affected the natural enemy predator population in onion cropping system. Use of acephate insecticide was also stopped as it was harmful to natural enemies and was bad smelling and not easily preferred by the onion growers. During 2014-15, validated IPM technology was further refined and revalidated on the entire onion area of about 80 acres in Singohi-Singoha-Rambha villages, which involved 60 farming families. Instead of applying FYM in nursery, rice husk ash mixing in soil was initiated because of its free availability, its being lighter than FYM, rich source of potash and its uniform spread in field without its accumulation as in FYM along the flow of irrigation water in nursery. The dipping of seedlings in *Pseudomonas fluorescence* solution at planting was not found to be practical with the onion growers and instead *P. fluorescence* solution was sprayed at 40 DAT as PGPR (Bandi and Sivasubramanium 2012, Naik *et al* 2015).

Weekly observations on the population of thrips (both nymphs and adults) (Shelton *et al* 1987), predatory spiders and syrphid flies per plant were recorded in 20 randomly selected plants from each field. Weekly severity of important disease, i.e. *Stemphylium* blight as per standard method (Mayee and Datar 1986) was adopted which was done on rating scale based on leaf area covered by the pustules. Weekly means of population of thrips and severity of *Stemphylium* blight (PDI%) over the season were computed and presented in the Table 1. For economic analysis, number of chemical sprays, biopesticide sprays, cost of cultivation including plant protection (₹/ha), yield (tonnes/ha), net returns (₹/ha) and C:B ratios were computed (Table 2).

RESULTS AND DISCUSSION

The adoption of IPM technology resulted in significant reduction in incidence of the thrips and *Stemphylium* blight and incidence of these pests was marginally higher in FP fields (Table 1) as against IPM fields. Trend and appearance of both the pests was similar during all these years under trial, i.e. 2012-13, 2013-14 and 2014-15 except minor variations when there was either excessive rainfall or drought either during January-February or March-April which affected the disease occurrence.

Pest incidence

Damping off though low in severity, was effectively managed by adding *Trichoderma* enriched FYM. Several growers also used rice husk ash in nurseries especially for soil improvement and easy uprooting of seedlings etc. Thrips population increased initially from first week of March, i.e at bulb initiation stage at 50 DAT which was the most critical growth stage and usually population remained high with the increase in temperature during bulb development

Table 1 Pest and natural enemy scenario in IPM and non-IPM onion fields during 2012-15 in Karnal, Haryana

Pest/natural enemy	2012-13		2013-14		2014-15	
	IPM	FP	IPM	FP	IPM	FP
Thrips/plant	5.1	9.2	4.7	11.2	3.8	11.5
Stemphylium blight (PDI)	4.8	23.5	12.1	28.8	16.7	32.3
Onion yellow dwarf (%)	0.4	1.2	0.7	1.1	1.6	2.0
Predatory spiders/ 10 plants	2.0	1.0	1.8	0.2	1.4	0.4
Syrphid flies/10 plants	1.8	0.6	1.8	0.4	2.0	0.6

Table 2 Economic analysis of IPM and non-IPM technologies in onion fields during 2012-15 in Karnal (Haryana)

Parameter	2012-13		2013-14		2014-15	
	IPM	FP	IPM	FP	IPM	FP
Number of pesticide sprays	5.3 (1)	8.7 (0)	5.0 (1)	9.2 (0)	5 (2)	6.2 (0)
Cost of pesticide sprays	7687.5	6625	6450.0	8175.0	6137.5	7887.5
Cost of cultivation including plant protection (₹/ha)	80575.0	80762.5	77462.5	79117.0	91600.0	93350.0
Onion yield (t/ ha)	18.13	16.58	28.62	27.50	16.00	14.86
Gross returns (₹/ ha)	180525.0*	165091.3	321750.0**	309100.0	159125.0***	147782.7
Net returns (₹/ ha)	99950.0	84328.8	244287.5	229982.5	67525.0	54432.7
Cost: benefit ratio	1:2.24	1:2.04	1:4.15	1:3.90	1:1.73	1:1.58

*Wholesale market rate in May ₹ 9950/tonne (2013), ₹ 11000 (2014); ₹ 9945/tonne (2015). Figures in parentheses indicate the number of biopesticides used.

till maturity. Lower thrips population of 5.1, 4.7 and 3.8 per plant in IPM as against higher population of 9.2, 14.2 and 11.5 per plant in non IPM fields was observed during 2012-13, 2013-14 and 2014-15, respectively (Table 1).Only one spray of ecofriendly green labelled spinosad 45 SC (75 g a.i/ha or 0.4 ml/litre) and need based spray of profenophos 50 EC @ 0.1% in IPM fields, irrigating fields using sprinkler and giving adequate irrigation during growing season were critical factors and could keep the thrips population at reasonably low levels throughout the crop season as against non-IPM fields where random, non-selective and unnecessarily excessive number of insecticides were applied by farmers (Table 2). Initially during 2012-13, two sprays of spinosad application increased the cost of plant protection, which was brought down to one spray in subsequent years. While applying pesticides with high pressure and spray volume in IPM fields, utmost care was taken to see that the spray fluid reached base of the leaves where majority of the thrips were located. Blue coloured sticky traps used for thrips detection and monitoring during 2012-13 were stopped in subsequent years as these attracted large number of syrphid predators. Sardana *et al*. (2012), reported green labelled biopesticide spinosad to be highly effective against thrips in bell pepper. Thrips population build up during 2014-15 in general was observed to be lower in IPM as well as non-IPM onion fields as against during 2012-13 and 2013-14 because of unseasonal rains received during March-April which is time for bulb formation and thrips multiplication and build up. *Stemphylium* blight caused by *Stemphylium vesicarium* was the major disease observed during three years 2012-15 of IPM programme which was initiated in March-April at 3-4 leaf stage and reached its peak at harvest in May-June.Young plants are infected earlier because of their close proximity to soil containing disease debris of preceding crop. *Stemphylium vesicarium* is known to sporulate abundantly in decaying vegetable matter in soil (Miller 1978). With the interventions of prophylactic and need based spray of mancozeb 75 WP and propiconazole 25 EC @ 0.1% in IPM fields, *Stemphylium* blight severity was significantly kept under check to lower levels of 4.8, 12.1 and 16.7 (PDI) during 2012-13, 2013-14 and 2014-15, respectively, as against high severity levels of 23.5, 28.8 and 32.3% in FP onion fields where only non-selective and mixtures of fungicides were applied. It was also observed that unseasonal rains during late January – February delayed transplanting in few fields which though had lower incidence but at the same time lower yields were obtained while timely planted crop by mid-January had higher disease incidence and higher yields as it was managed by timely and prophylactic spray of fungicide. Crop which was transplanted in November had developed more bolts than bulbs indicating the importance of timely planting for less disease development and higher yields. Yellow dwarf though observed in IPM as well as non-IPM fields was extremely low and did not warrant any chemical intervention.

Natural enemies

Only predatory spiders and syrphid flies as natural enemies were observed in onion fields in fairly good numbers. Marginally higher population of syrphid flies and predatory spiders in IPM fields (1.8, 1.8, 2.0 and 2.0, 1.8, 1.4/ 10 plants, respectively) than non-IPM fields (0.6, 0.4, 0.6 and 1.0, 0.2, 0.4/10 plants, respectively) was observed (Table 1). These predators were present during April-May only when there was maximum crop growth/ canopy. IPM technology implementation thus resulted in increased biodiversity. Sardana *et al*. (2014, 2012) also concluded that integrated pest management schedule was safer to syrphid flies and predatory spiders in onion and bell pepper ecosystems.

Economic viability

The mean yield obtained was higher, i.e 18.13, 28.62 and 16.00 tonnes/ha in IPM fields than farmer's practices fields where it was 16.58, 27.50 and 14.86 tonnes/ha, during 2012-13, 2013-14 and 2014-15, respectively. Occurrence of unseasonal rains during January-February 2012-13, caused delayed transplanting of onion seedlings resulting in lower yields while unprecedented unseasonal rains along with strong winds during March-April 2015, badly affected the setting/bulb formation resulting in small sized bulbs which ultimately affected the onion yield and market rates very badly in both IPM and non-IPM fields. In the present studies, it was also inferred that apart from insect pests and diseases, unseasonal rains also impacted the disease development and onion crop yields.

The cost of cultivation including plant protection was comparatively lower in IPM fields (₹ 80 575, 77 462, and 91 600/ha) as against non-IPM fields (₹ 80 762, 79 117 and 93 350/ha) during 2012-13, 2013-14 and 2014-15, respectively. The data further revealed that the application of spinosad biopesticide, *Trichoderma* in nursery and *Pseudomonas fluorescence* spray and need-based application of eco-friendly, optimal dose, green labelled pesticides was highly effective in reducing the pest population, which in turn resulted in increased yield to some extent. Moreover, adoption of IPM technology under expert supervision over the three years , i.e. 2012-13, 2013-14 and 2014-15 resulted in reducing the number of chemical pesticide sprays to three from 8-9 in non-IPM fields along with production of higher onion yield in IPM fields with higher C:B ratios (Table 2). Tripathi *et al*. (2013) and Sardana *et al*. (2012) reported higher yields and CB ratios in IPM managed onion and bell pepper fields, respectively.

IPM technology used was not only directly environment friendly but also more sustainable vide increase in biodiversity (natural enemies, soil flora and fauna) due to less load of pesticides. Feedback from the IPM farmers also indicated the increased knowledge, awareness and adoption of 75% of the IPM components for onion crop by majority of the adopted farmers. Adoption of IPM technology enabled the farmers to differentiate between the pests and bio- agents, increased knowledge about biopesticide, economic threshold levels, identification of natural enemies and avoidance of widely prevalent practice of using the mixtures of pesticides.

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