SURVEY AND MANAGEMENT OF *THRIPS TABACI* (LINDEMAN) AND *SPODOPTERA* SPP. ON ONION CROP IN HYDERABAD-KARNATAKA REGION

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CERTIFICATE

This is to certify that the thesis entitled **"SURVEY AND MANAGEMENT OF *THRIPS TABACI* (LINDEMAN) AND *SPODOPTERA* SPP. ON ONION CROP IN HYDERABAD – KARNATAKA REGION"** submitted by **Mr. SURESH GOVINDRAO** for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL ENTOMOLOGY** to the University of Agricultural Sciences, Raichur, is a record of research work carried out by him during the period of his study in this University, under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

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Date: AUGUST, 2013

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(Y.S. AMARESH)

Affectionately Dedicated

To

My Beloved Parents,

Sri Govindrao and Smt. Shakuntala

Brother, Balaji and Dattu

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With regardful memories……

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LIST OF ABBREVIATIONS

et al.	:	And other people
Anon	:	Anonymous
Fig.	:	Figure
ha	:	Hectares
g	:	Grams
ml	:	Millilitre
SC	:	Soluble concentrate
S.Em	:	Standard error of mean
CD	:	Critical difference
WSP	:	Wettable soluble powder
kg	:	kilogram
DAS	:	Days after spray
DBS	:	Days before spray
m	:	meters
l	:	litres
a.i.	:	Active ingredient
/	:	per
%	:	Per cent
i.e.,	:	That is
@	:	at

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INTRODUCTION

I. INTRODUCTION

Onion (*Allium cepa* L.) belonging to the family Amaryllidaceae is one of the most important commercial vegetable crops grown in India. It is extremely important vegetable crop not only for internal consumption but also as highest foreign exchange earner among the vegetables. Onion is second only to tomato in their importance as a vegetable in tropics. Irrespective of price, the demand for onion remains almost constant in the market as it is primarily used as a food seasoning for a wide variety of dishes in many homes almost daily.

Onion, *Allium cepa*, originates from Central Asia (between Turkmenistan and Afghanistan) where some of its relatives are still grown in the wild. Amongst the onion producing countries in the world India ranks second in area and production after China. India has an area of 1064 million hectares with a production of 15117.7 million tonnes with an yield of 812.25 kg/ha (Anon., 2011). In Karnataka the area is 0.19 million ha with a production of 2.59 million tonnes and productivity of 13.6 mt/ha (Anon., 2011).

The onion (*Allium cepa* L.) has widely been used even in ancient time as a food seasoning and also as a natural medicine. Onion is an important and indispensable item in every kitchen as condiment and vegetable, hence commands, an extensive internal market. The green leaves and immature and mature bulb are eaten raw or used in preparation of vegetables. In current times, the onion is an important vegetable that is served as an ingredient in dishes, as toppings on burgers, in seasonings and as chip coatings (Sharma *et al.*, 2005). Onions find widespread usage in both fresh and dried forms. Dried onions are a product of considerable importance in world trade and are made in several forms that include flaked, minced, chopped and powdered onions (Kumar *et al.*, 2006). Many medicinal properties of onions are diuretic, applied on bruises and wounds. It also helps in preventing the heart diseases (Augusti, 1990).

Onion is cool season crop. However, it can be grown under wide range of climatic conditions. It grows well under mild climate without extreme heat or cold or excess rainfall. It requires cool, moist conditions for early growth, followed by warm, drier conditions for maturation. In south India August – September is most suitable time for *kharif* crop and it is October – November for *rabi* crop in plains (Bose *et al*., 2003). Onion plants are grown by various means like transplanting of seedling, planting bulbs, direct sowing of seeds in main field by broadcasting, crop by sets, *etc*. among all those, the cultivation of onion through transplanting of seedlings is more commonly practiced for an irrigated crop by the Indian farmers.

Insect pests play an important role in reducing onion yield specially, thrips (*Thrips tabaci* Lindeman), armyworm, *Spodoptera litura, S. exigua,* onion maggot (*Delia antiqua* Meigen), cutworm *(Agrotis segetum* Schiff) are the major pests and aphids *(Myzus ascalornicus* Doncaster) and bulb mites *(Rhizoglyphus sp.*) are being miner. Among the insect pests, onion thrips, *T. tabaci* is a most serious pest found in onion-growing regions worldwide (Lewis, 1997a and Brewster, 1994) and causing loss upto 41 per cent of yield of onion bulbs (Raheja, 1973). Onion thrips are polyphagous and have been recorded on more than 300 species of plants (Straub and Emmett, 1992). The thrips population was correlated negatively with relative humidity and positively with temperature. A population of 10 thrips per plant and temperature around 29 ^{o}C coupled with dry season could cause serious damages to the onion crop. *Thrips tabaci* is considered to be the principal onion pest in U.S.A, where it can cause yield reductions by feeding on the epidermal cells of the plant, thus reducing the photosynthetic ability of the plant (Jensen *et al.,* 2003). Purple blotch and onion thrips are of national importance and thrips infestation was observed both in winter and summer crop and number of thrips per plant varied from 0.2 to 30.3 (Gupta *et al*., 2011). In India, the thrips are active throughout the year and breed on onion from November to May.

Onion is an important vegetable crop of Hyderabad – Karnataka region and farmers take up sowing in August and September. It is seriously affected by onion thrips, necessitating farmers to take up spray at different times of growing season. Farmers apply chemicals indiscriminately whenever presence of thrips population is noticed on onion. But information on the optimum time for planting as well as suitable plant protection schedule for management is lacking on onion crop. In this context the present study encompassing, survey, different dates of transplanting, seasonal incidence and management is appropriate and it is the need of the hour. Hence, investigations were carried out with the following objectives.

1. To undertake survey on the incidence of insect pests and their natural enemies on onion in Hyderabad–Karnataka region
2. To know the influence of dates of transplanting on insect pests of onion
3. To find out optimum plant protection schedule for management of insect pests of onion.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

Review of work done on the onion insects pests and natural enemies pertaining to survey, dates of transplanting and management are presented below.

2.1 Survey on the incidence of insect pests and their natural enemies of onion.

2.1.1 Onion thrips

Thrips tabaci populations thrive in warm and fairly dry conditions, which not only promote fast larval development but are ideal for flight, the primary means by which the thrips migrate between hosts (Harding, 1961; Kirk; 1997; Lewis, 1997b and Lewis, 1997c).

Raheja (1973) reported that population of thrips gradually built up and reached a peak 50 days after transplanting. Few thrips were present on onion crop until mid-February and there was a sudden increase in numbers to peak levels during the first week of April reported by Kisha (1977).

Kranz *et al*. (1977) reported that number of thrips on a crop can increase rapidly in dry weather and decrease rapidly after rain. It was found that large number of thrips attacking a crop at the seedling stage could cause severe or even total loss to onion. Salguero e*t al*. (1991) reported that host plant phenology played an important role in population dynamics, with younger plants being able to support greater densities than older plants, but this was found to be true with onions transplanted in February and March.

During the vegetative stage, *T. tabaci* populations were concentrated on the center leaves but progressively populations became equally distributed all over the leaves. Sites *et al.* (1992) and Domiciano *et al.* (1993) evaluated the population fluctuation of *T. tabaci* on onion at three sowing times and the relation with climatic elements, as well as the best time for control. Result revealed that thrips population was correlated negatively with relative humidity and positively with temperature. Factors that influence these population changes is essential in predicting thrips population. Weather variables including rainfall, temperature, relative humidity and wind have been reported as important factors that significantly affect thrips numbers (Ananthakrishnan, 1993; Kirk, 1997 and Legutowska, 1997). Hamdy and Salem (1994) reported that relatively high temperatures and lack of rainfall were associated with increase in onion thrips population, while high relative humidity and rainfall reduced thrips population.

In the absence of any control measures, infestations on yellow onions by thrips resulted in 34.5 and 43 per cent yield loss during two climatically different years with seasonal averages of 149 and 172 thrips per plant respectively, in untreated plots. (Fournier *et al.*, 1995) Hussain *et al.* (1997) reported that population of the *Thrips tabaci* began to build up in early February and reached maximum during April. Hamdy and Salem (1994) reported positive, while Warriach *et al.* (1994) said negative and El-Gendi (1998) reported that there was no correlation between maximum temperature and thrips populations. Relative humidity and rainfall had a negative effect on thrips population. Thrips were especially problematic during hot, dry years as more number of generations were produced and mortality was due to lack of rainfall (Shelton, 2003). According to a study two population peaks one in the month of August, and the other in January - February, occurred in western Maharashtra as reported by Srinivas and Lawande (2004).

The adult thrips were captured on white sticky traps as early as mid-May month and were not recorded on onion plants in these fields until late June and early July. A comparison of sticky trap captures to plant counts revealed a strong, positive correlation, indicating that sticky traps, which consistently detected thrips earlier than plant counts as reported by Macintyre *et al.* (2005). Alfredo *et al*. (2007) studied seasonal abundance and effect on onion yield reduction by onion thrips, *Thrips tabaci* for two consecutive seasons (dry and rainy) to develop economic thresholds (ET). Result revealed that thrips populations was highest during the dry season, with an average of 5.2 times more thrips per leaf per day then during the rainy season.

Mo *et al.* (2008) observed that when onion plants were young and *T. tabaci* densities were low, higher numbers of larvae than adults gathered at the base of plants. When onion plants matured the densities increased and the larvae dispersed to other parts of the leaves. Waiganjo *et al.* (2008) studied effect of weather on thrips population in onions with the aim of predicting thrips control requirements for a given climatic trend. Weather variables monitored included: rainfall, temperature, relative humidity and wind. Thrips occurred in the onion field and infested onions in all the crop seasons. However, there was significant (P=0.05) variation in thrips numbers between the crop seasons. Dry weather (30.3 mm rainfall) with moderately high temperatures (15.6-28.2 ^{o}C) increased seasonal thrips numbers, while wet season (391 mm rainfall) with moderately high relative humidity was negatively correlated with thrips numbers. Regression analysis showed that minimum relative humidity was the only significant weather factor for predicting thrips infestation on the crop.

Farman *et al*. (2010) studied population dynamics of onion thrips at Peshawar, Pakistan and noticed that the activity of onion thrips (*Thrips tabaci)* started from 3rd February onwards (1.20 thrips/plant) and reached its peak (100 thrips/plant) during the last week of April.

2.1.2 Defoliators

Ulrichs and Mewis (2004) studied two armyworm species *viz., Spodoptera exigua* (Hübner) *and S. litura* (F.) wherein the population densities were recorded weekly using pheromone traps. Both armyworm species were present throughout the year at both observation sites. No differences in number of males trapped in pheromone traps between seasons was found for *S. litura*. Whereas the number of male *S. exigua* trapped during rainy season was significantly higher than dry season.

Sailaja *et al.* (2006) carried out a field experiment during *rabi* season to study the influence of weather parameters on the population dynamics of *Spodoptera litura* (F.) and *Spodoptera exigua* (Hb.) on onion. The pest activity was observed for ten weeks commencing from the 46^{th} to 3^{rd} standard week with a peak larval density of 23.83 per ten plants during the 52^{nd} standard week with respect to *S. litura* and 21.03 per ten plants during the 1st standard week in the case of *S. exigua*. There was a significant and negative correlation between the larval population of both the pests and minimum temperature, morning and evening relative humidity and rainfall exhibited non significant and negative relationship with the population of *S. litura* infesting onion crop.

2.1.3 Onion maggot

Tanzubil *et al*. (1999) studied the incidence and distribution of onion fly, *Delia antiqua* and results showed that the insect was prevalent in most of the onion-growing areas and was capable of causing up to 33 per cent crop damage. It was also established that early transplanting (Before mid-January) and transplanting of seedlings six weeks after emergence reduced *D. antiqua* infestation and crop damage.

The seasonal occurrence and emergence patterns of the onion pest *Delia antiqua* revealed the anthomyiid had three generations per year. According to Park *et al.* (1990) the peaks of adult occurrence were in mid-April for the over wintered generation (first flight), in early June for the first generation (second flight), and from late September to early October for the autumn generation (third flight). Some of the pupae in the first and almost all of the pupae in the second generation underwent summer diapause.

2.1.4 Natural enemies

Saxena (1975) recommended a combination of resistant cultivars and releases of predators, where he observed that *Chrysopa* spp. suppressed onion thrips population with judicious application of insecticides during peak period of infestations. Thrips species were attacked by several groups of generalist predators including Coleoptera, Diptera, Neuroptera, Hemiptera and Acari (Waterhouse and Norris, 1989 and Kirk, 1997).

Elaine and Brian (2012) reported onion thrips, *Thrips tabaci* Lindeman (Thysanoptera: Thripidae), as a major insect pest of dry bulb onions (*Allium cepa*) in New York. Surveys for natural enemies and onion thrips conducted in small plots of onions transplanted at different location revealed that the most commonly encountered natural enemies on all farms included predatory thrips (aeolothripidae), hoverfly larvae (syrphidae), ladybird beetles (coccinellidae), lacewing larvae (chrysopidae) and minute pirate bugs (anthocoridae). The natural enemy abundance was similar across all farms and did not change through time ($P>0.05$) and more natural enemies were found on high habitat diversity farms than low diversity ones ($P=0.0386$) and more number were observed in mid-July ($P<0.001$) during the study period. Joe (2012) reported eight beneficial predators and parasite families from three fields. The average of all populations of insects and arachnids at all locations revealed that ladybird beetle larva were the most numerous followed by spiders, braconid wasps, syrphid flies, big eyed bugs, ladybird beetle adults, nabids and lacewings. No statistical differences in beneficial populations were seen between the three locations. Six plant feeding insect families and one phytophagous mite family were found in the field samples. Only mite and thrips population varied significantly between the three locations.

2.2 Influence of dates of sowing on insects pests of onion.

2.2.1 Onion thrips

The number of thrips were low during February, probably because the temperature was relatively low, 25 – 26 °C, according to Franssen and Huisman (1958) the infestation of *Thrips angusticeps* Uzel during rainy and cool seasons were significantly lower than those during dry and hot seasons, may be because of high larval mortality and slower population growth rates (Kirk, 1997).

Kisha (1977) stated that early transplanted onions were usually well established before attack began in mid February and added that a mean of 5-10 nymphs/plant be adopted as a critical level at which commencement of control measures can be made. Burgstaller and Hassan (1984) reported that onion transplanted in October and November were well-established before the thrips infestation (January-February) and usually produce high yield without application of insecticides. Malik *et al*. (2003) reported that in the March transplanted onion, thrips appeared during the second week of April with a maximum number of thrips (162.4 per plant), in which yield reduction was observed upto 20.76 per cent.

Reuda and Shelton (2003) reported that at the end of the season, thrips might not be able to survive in abundance because there was no sufficient green vegetation in the surrounding areas and April, May being the driest months of the year and June-September months had heavy rains which maintained thrips population at low level. The population of thrips was low up to the middle of February in November and December transplanted crops. The population during March was above 100 thrips per plant.

Aswathanarayana and Gowdar (2005) conducted field trials to know the most appropriate sowing date to minimize the incidence of onion thrips, *Thrips tabaci* and purple blotch caused by *Alternaria porri* in onion. The minimum thrips incidence was observed on 5th August sowing (7.41 numbers/plant) and in 15th August sowing (5.36 thrips/ plant). Maximum thrips infestation was recorded in 5th July sowing (20.7 thrips/ plant and 11.4 thrips/plant).The highest disease intensity was recorded in early sown crop (June and July), followed by gradually declining disease intensity in later sown crop (August and September) during both the years. Highest bulb yield was obtained in 5th August (17.90 t/ha) and 15th August sowing (19.80 t/ha respectively). Hence, sowing during 5th to 25th August was advantageous for thrips and disease control with higher bulb yields.

Morsello *et al.* (2008) observed that seasonal aerial trapping showed that very little movement of both *Frankliniella fusca* Pergande and *T. tabaci* from January to March of each year. During early April and May there was increase in *F. fusca* or *T. tabaci* and reached peak between 10 and 31 May each year. Ibrahim and Adesiyun (2009) studied different time intervals of onion transplanting to assess the thrips population and found that November and December transplanted onions were free of thrips up to ninth and eighth week after transplanting respectively and January transplanted up to six weeks after transplanting. While February, March and April transplanted crop had population of more than five thrips per plant at four WAT.

Ibrahim and Adesiyun (2010a) studied on transplanting of onion seedlings from November to March to study the population dynamics and found that early transplant (November) had peak thrips population at maturity and middle transplant recorded the peak population in the middle of the season and late transplant had their peaks in early part of the growing season.

Ibrahim and Adesiyun (2010b) investigated transplanting date and insecticide frequency on population of thrips in onion. Results revealed that early transplanting done in November and December had fewer thrips than the subsequent ones and first spray was very effective in reducing thrips by 76 per cent as compared to second and subsequent sprays.

Ibrahim and Adesiyun (2010c) studied the major insect pests of onion using five dates of transplanting and five insecticidal spray regimes of λ-cyhalothrin. The results indicated that thrips were the major insect pests of onion, which started colonizing onion plant in December, but the number was low until the third week of January and peaked in mid-March with 600 thrips per plant. Rainfall controlled thrips than either planting date or the chemical (78%). There was a reduction in thrips population from 86 to 9 thrips per plant (89%) in zero spray in March transplant and in February transplant the reduction was from 78 to 13 thrips per plant. Where rainfall can be simulated, a greater control can be achieved, where thrips are washed away by the force of the rain, unlike chemical that may not reach the innermost leaves.

Lawande (2011) studied the impact of planting dates on onion thrips. Highest thrips population was noticed in the crop planted during February (98.62/plant) followed by January (44.76/plant). *Rabi* planting recorded thrips population from 6.13 to 98.62 per plant. Whereas during *kharif*, highest thrips were noticed in August (26.20 nymph/plant).

Marketable yield was very low in *kharif* season planting (3.01 t/ha), highest yield was recorded in December planting (35.07 t/ha).

2.2.2 Defoliators

Chen *et al.* (2001) noticed the peak occurrence of *Spodoptera exigua* (beta armyworm) in August and September. Adamczyk *et al*. (2002) studied the annual profile of beet armyworm populations in the western section of the Mississippi Delta and results revealed that wide-scale immigration of this pest typically began at 200 Julian days (mid-July).

Studied on transplanting of onion seedlings from November to March to study the population dynamics revealed that early transplant (November) had peak thrips population at maturity and middle transplant recorded the peak population in middle of the season and late transplant had their peaks in early part of the growing season (Ibrahim and Adesiyun, 2010a). The population of *Spodoptera litura* (F.) and *Spodoptera exigua* (Hb.) activity was observed for ten weeks commencing from the 46th to 3rd standard week with a peak larval density of 23.83 per ten plants during the 52nd standard week with respect to *S. litura* and 21.03 per ten plants during the 1st standard week in the case of *S. exigua* (Sailaja *et al.*, 2006).

2.3 Optimising plant protection schedule for management of insect pests of onion

2.3.1 Onion thrips

Fair control of adult thrips in onion was obtained by spraying dimethoate at 1.5 lb/ac (Rowland and Wilcox, 1966). Demniano (1967) observed that malathion, dimethoate and dicrotophos sprays at 0.03 per cent were somewhat less effective when compared to phosphofolan and fenitrothion. Rossiter and Giesemann (1976) have tested 16 insecticides against the control of thrips on onion and none of the insecticides tested afforded good control. Best results were obtained with 0.05 per cent dimethoate and methidathion at 1120 or 1685 l/ha.

Straub and Davis (1978) evaluated standard control insecticides *viz.*, diazinon, fensulfothion and fonofos in nine trials conducted at four locations for three years and it was found that the candidate materials carbofuran, chlorpyrifos, diethyl phosphorothioate and terbufos provided equal or better protection than the best standard materials. Dimethoate at 0.5 kg a.i./ha was ineffective in the control of thrips after four days, however on 12th day it was still superior to untreated checks as reported by Jaganmohan and Krishnakumar (1980).

A field experiment was carried out in Maharashtra and revealed that all the three insecticides *viz.*, parathion, dimethoate and monocrotophos used against thrips were effective in reducing the pest after six hour (Mote, 1981). Srinivasan (1982) noticed that monocrotophos and dimethoate resulted in comparatively less number of thrips per plant, at all intervals after spray. However, differences among the chemicals were not significant and were on par with each other. Spraying the infested plants with water also resulted in significant reduction of thrips population to 22.30, 24.15 and 9.15 per cent at 1, 2 and 10 days after application, respectively. Among the insecticide tested, maximum reduction was noticed with monocrotophos (98-92%) and dimethoate (97-62%) after 10 days of spraying.

Deltamethrin 0.002 per cent and cypermethrin 0.006 per cent proved most effective against onion thrips *T. tabaci* followed by endosulfan, fenitrothion, dichlorvas, malathion each at 0.05 per cent and fenvalerate 0.006 per cent, oxydemeton methyl 0.025 per cent, dimethoate 0.03 per cent and monocrotophos @ 0.04 per cent were inferior to all other insecticides, except malathion and fenvalerate (Saini *et al.*, 1989). Sato and Nakano (1990) evaluated different pyrethroids against *T. tabaci* on onion crop which revealed that deltamethrin at eight g a.i./ha gave more than 94 per cent control, whereas, aldicarb and carbofuran at 2.0 kg a.i./ha applied to the soil surface 21 days after transplanting, had more than 70 per cent of thrips control upto 28 days of application.

Marvin Butler *et al.* (1995) evaluated different insecticides *viz.*, imidacloprid, chlorpyrifos, lambdacyhlothrin, bifenthrin, and carbofuran against onion thrips on the crops grown for commercial seed purpose. Result revealed that furadan provided the greatest control compared to other chemical treatments. Shelton *et al.* (1998) reported that onion varieties and insecticide application in combination significantly affected thrips damage and also observed that even frequent application of insecticides was not sufficient to keep thrips damage at low and planting tolerant varieties, was however a reliable way to keep thrips damage at low levels, even without insecticides. Muhammad *et al.* (2003) evaluated synthetic insecticide (monocrotophos 40WSL) and three botanical infusions (datura Alba Seed Extract Infusion, SEI; *Calotropis procera* Latex Infusion, LI and *Citrullus colocynthus* fruit extract infusion, FEI) against onion thrips. All tested insecticides caused mortality of onion thrips at various degrees of significance over untreated control. *C. procera* LI, proved itself the best among the tested botanical insecticides and provided 42.67 per cent control after monocrotophos that caused 76.24 per cent mortality of onion thrips. *D. Alba* SEI *and C. colocynthus* FEI showed minimal control of pest than other tested insecticides but the results encourage the idea of pollution free methods of pest control, where *C. procera* LI can be used as a good botanical insecticide in Integrated Pest Management (IPM) of onion thrips.

Waiganjo *et al*. (2004) made studies on onion seed coated with thiamethoxam 350g, seedling drenching with Neem oil *Azadirachtin* 0.15 per cent w/w, seedling drenching with neem powder *Azadirachtin*, 0.03 per cent w/w, seedling drenching with imidacloprid 200 g/l, overnight seedling dipping in imidacloprid and soil placement with carbofuran 5 per cent during transplanting. These single dose treatments were compared with profenofos 400 g/l plus cypermethrin 40g/l fortnightly foliar spray and unprotected control. All the preventive treatments reduced thrips infestation significantly (P=0.05), except seedling drenching with *Azadirachtin* which was not effective. imidacloprid seedling drenching and carbofuran soil placement had the longest residual effect and significantly increased onion bulb yield and quality.

Jennifer *et al*. (2005) reported that foliar application of spinosad 480 F and novaluron 0.83 EC or 0.86 EC significantly reduced onion thrips populations. In addition to foliar sprays, application of imidacloprid as a seed treatment 480 FL delayed development of onion thrips populations. Patil *et al.* (2009) evaluated new insecticides and bio-insecticides *viz., Beaveria bassiana* 4 g/l, Neem seed Kernel Extract 5 per cent, *Verticilium lecanni* 2 x 108 CFU 5 g/l, methyl demeton 25 EC @ 0.025 per cent, carbosulfan 25 EC @ 0.025 per cent, spinosad 45 SC @ 0.0135 per cent, deltamethrin 1 EC + triazophos 35 EC @ 0.072 per cent, indoxacarb 14.5 SC @ 0.0145 per cent, flufenoxuran 10 DC @ 0.005 per cent and novaluran 10 EC @ 0.01 per cent and found that all the treatments were significantly effective against control of onion thrips. The treatment with deltamethrin 1 EC + triazophos 35 EC @ 0.072 per cent proved to be significantly most effective against onion thrips which recorded minimum number of thrips/plant. This treatment was statistically at par with spinosad 45 SC @ 0.0135 per cent and carbosulfan 25 EC 0.025 per cent.

Farman *et al.* (2010) studied the effect of different insecticide treatment on onion thrips (*Thrips tabaci*, Lindermann) and found that all the insecticides like Thiodan, Confidor, Tracer and Megamos, except Actara, all were significantly effective against the pest as compared to control. Hosamani *et al.* (2012) investigated new formulation of fipronil against thrips during 2010 and 2011, for two consecutive years and the result revealed that fipronil 80 WG @ 60 g a.i./ha was effective in reducing the thrips populations with increased yield of onion.

Lawande (2011) conducted field trial during *rabi* season to evaluate bio-efficacy of fipronil 80 WG, against onion thrips. Three doses of fipronil *viz.*, 50, 62.5, 75 g/ha and lambda cyhalothrin 750 ml/ha, cyper.+ chlor. 750 ml/ha, profenofos 500 ml/ha were sprayed five times. During the period of study highest thrips infestation of 11.20 per plant was recorded in Lambda cyhalothrin and lowest thrips infestation of 0.87 per plant was seen with use of profenofos whereas in control it recorded 33.47 thrips per plant. Bio-efficacy of fipronil ranged between 0.87 – 11.20 thrips per plant in five sprays.

Gupta *et al.* (2011) found that sequential spraying of deltamethrin @ 0.095 per cent, carbosulfan 25 EC @ 0.2 per cent, fipronil @ 0.1 per cent and thiomethoxam 25 WG @ 0.2 per cent at 15 days interval performed better in reducing thrips population (8.84 nymph/ plant) compared to control with 36.73 nymph per plant and 27.08 nymphs per plant in check (4 sprays of deltamethrin @ 0.095%), sequential spray of carbosulfan 25 EC @ 0.2 per cent, lambda cyhalothrin @ 0.05 per cent, acetamapride 10 EC @ 0.01 per cent and alfamethrin 10 EC @ 0.15 per cent at 15 days interval performed better in reducing thrips population (15.23 nymph/plant) as well as giving higher yield (293.19 q/ha) as compared to control with 43.21 nymph per plant and 187.75 q/ha gross yield, the check (4 sprays of deltamethrin @ 0.095%) recorded 17.17 nymph per plant but yield was 208.90 q/ha.

A pot experiment was conducted by Gupta (2012) to evaluate different entomopathogenic fungi for the management of onion thrips. Different entomopathogenic fungi *viz*., *Beauveria bassiana* @ 4.0 ml/l, *Verticillium lecanii* @ 2.5 g/l, *Paecilomyces fumosoroseus* @ 4.0 g/l, *Verticillium lecanii* + *Metarhizium* + *Beauveria bassiana* (mixed biopesticides) @ 1.0 ml/l, along with control plot (only water spray) were tested against onion thrips. Lowest mean thrips population (13.15 nymph/plant) was recorded in combined bio pesticides (*Verticillium lecanii* + *Metarhizium* + *Beauveria bassiana* @ 1.0 ml/l) followed by *Verticillium lecanii* @ with 13.81 nymph/plant and highest mean thrips (20.74 nymph/plant) were recorded in control plot.

The relative toxicity of different bio-rational insecticides against second instar larvae and adults of onion thrips, *T. tabaci* were tested by *(*Mahmoud and Mohamed, 2007) in experimental farm and in the laboratory. Eight insecticides dipel 2x, biofly, agrin, bioguard, spinosad, neemix, mectin and match were evaluated for their relative toxicity towards *T. tabaci* with recommended dose, half of recommended dose and quarter of recommended dose in the laboratory and only recommended dose under field conditions. Spinosad was the most effective insecticide against second instar larvae followed by agrin, match and dipel 2x. Toxicity index values at LC 50 level showed such superior efficiency of spinosad (100%) when applied against adults and second instar larvae of onion thrips under laboratory conditions. All insecticides under field conditions caused reduction of infestations of thrips.

2.3.2 Defoliators

Dingxu *et al.* (2003) selected insecticides like, polo, chlorfenapyr, xentari and mimic from ten screened insecticides through their indoor toxicity evaluations and field effectiveness tests. These insecticides were effective in preventing and controlling *Spodoptera exigua.* Among them, polo and chlorfenapyr had low toxicity, high efficient, long residual effect, which can be used as best insecticides in the years of *Spodoptera exigua* breakout. Jin (2009) studied twenty-five insecticides registered for spring onion against the beet armyworm in the laboratory, of which the best nine chemical and a single biological insecticides were selected and compared with two new isolates of *Bacillus thuringiensis* in a polyvinyl house. After that four chemical and three *B. thuringiensis* treatments were used in the field for the control of beet armyworm in the spring onion. Two application methods were used: one is triple treatments with the same chemical and the other is alternative application with different chemicals and *B. thuringiensis* at seven days intervals. Indoxacarb WP - chlorfluazuron EC - *Bt. var. kurstaki* CAB141 and indoxacarb WP - methoxyfenozide + spinosad SC - chlorfluazuron EC - *B.t. var. aizawai* CAB109, *B.t. var. kurstaki* CAB141 showed greater than 78 per cent mortality of beet armyworm. These results showed that alternative applications had higher control effect than any other applications. It was suggested that alternative applications with microbial biological agents such as *B. thuringiensis* might minimize the development of insecticide resistance and might be used as the environment-friendly for the control of the beet armyworm.

Sreenivas *et al*. (2013) evaluated eleven treatments comprising of organic and inorganic treatments and revealed that at all the intervals rynaxypyr 20 SC was found to be optimum treatment which recorded 1.18, 0.56, 0.66 and 0.86 *Spodoptera* larvae per plant at 1, 3 and 14 DAS, respectively. Whereas three days after spraying lufenuron and spinosad 48 SC were found to be on par with each other as they registered 1.2 and 1.3 *Spodoptera* larvae per plant, respectively. Further at seventh and fourteenth day of observation rynaxypyr 20 SC followed by novaluron 10 EC recorded 1.2 and 1.3 *Spodoptera* larvae per plant, respectively.

2.3.3 Onion maggot

Delaying planting as long as possible in the spring has been recommended as a method of cultural control for onion maggot (Doane and Chapman, 1952). Onion maggot adult activity may be concentrated along field edges. On a per field basis, more onion maggot flies have been trapped along field edges than in centers of field (Loosjes, 1976; Whitfield, 1981; Finch *et al*., 1986; Vernon *et al*., 1987 and Vernon *et al*., 1989). Brian *et al.* (2006) found that onion seeds film-coated with fipronil, spinosad and clothianidin provided excellent control of onion maggot, similarly, Taylor *et al.* (2008) evaluated the fipronil, spinosad and clothianidin as seed treatment chemicals and found that onion maggot damage was reduced by 76 to 97 per cent.

Pandey and Namgayal (2010) screened different insecticide for the management of onion maggot. The study revealed that the onion maggot caused 17.11 to 37.5 per cent infestation in onion in different area of Kargil district with highest and lowest infestation in Shilikchey and Baro village, respectively. Out of six insecticides *viz.,* phorate, dichlorvos, phosphamidon, endosulfan, chlorpyriphos and malathion, phosphamidon was found to be most effective insecticide at both concentrations *i.e.* 0.05 and 0.07 per cent by reducing 60.00 to 84.5 per cent infestation over control. However, it was almost at par with phorate which reduced 46.0 to 76.8 per cent infestation, respectively. The endosulfan, at both concentrations, was found to be least effective insecticide as compared to the rest of the test insecticide.

2.3.4 Natural enemies

Saxena (1975) recommended a combination of resistant cultivars and releases of predators, where he observed that *Chrysopa* spp suppressed onion thrips population with judicious application of insecticides during peak period of infestations. In this study, two predators were found *Exochomus flavipes* Thunberg (Coleoptera: Coccinellidae) and *Monolepta duplicata* Chujo (Coleoptera: Chrysomelidae).

Saxena (1983) reported that *Scymnus nubilus* Muls., *Laius externenotatus* Pic, *Orius albidipennis* (Reut.), *Chrysopa* sp. and *Aeolothrips collaris Priesn*. were found preying on *Thrips tabaci* Lind. in onion ecosystem in India. The predators consumed 23.2 to 96 thrips larvae per day, but their incidence was very low in comparison with that of their prey. Parasitism by *Ceranisus sp*. ranged from 2 to 18 per cent during the season, but the incidence of the parasite was low. Natural enemies observed in the unsprayed and organic treatments by Workman and Martin (2002) included *Ceranisius menes*, *Aeolothrips fasciatum*, *Buchananiella whitei*, syrphids and entomogenous fungi. None of these natural enemies increased sufficiently to provide effective thrips control.

Natural enemies of thrips, especially predators, play a significant role in suppressing thrips populations as reported by Hoffmann *et al*. (1996). Information on predators, hymenopterous parasitoids, parasitic nematodes and fungal pathogens of thrips has been reviewed by Loomans *et al*. (1997) and Butt and Brownbridge (1997). Tong-Xian Liu (2004) reported several species of predators on onion plants, including *Orius insidiosus* (Say), bigeyed bug, (*Geocoris punctipes* (Say)), assassin bug, (*Sinea spinipes* (Herrich-Schaeffer)), *Chrysoperla rufilabris* (Burmeister) and several species of lady beetles, spiders, predaceous mites, and rove beetles. Most predators found in this study were generalist predators. Generally, the number of predators were extremely low on either insecticide-treated plants or untreated plants in the early and mid-season, and peaked in the late season in April when thrips population peaked.

MATERIAL AND METHODS

III. MATERIAL AND METHODS

The present investigation on survey and seasonal incidence of major pests of onion (*Allium cepa* L.) was carried out in farmer's fields of major onion growing districts of Hyderabad Karnataka under protected conditions. Further, the influence of different dates of transplanting and management in respect of optimising plant protection schedule was carried out at Main Agricultural Research Station, Raichur, University of Agricultural Sciences, Raichur, Karnataka during 2012-13. Raichur is situated in North Eastern Dry Zone (Zone-2) of Karnataka between 16^{o} 15' N latitude, 77^{o} 20' E longitude and at 398.37 m above mean sea level. The average rainfall is 660 mm confined to monsoon period between June and November with occasional showers during pre-monsoon months of April and May with a mean maximum temperature is more than 30 ^{o}C throughout the year except during December. The relative humidity is high during monsoon months from July to September and uniformly low during summer months from March to May. Meteorological conditions prevailed during the experimentation period between June 2012 to February 2013 are presented in Appendix-I. The materials used and methodologies followed in conduct of these investigations are presented in detail as under.

3.1 Survey on insect pests and their natural enemies of onion in major onion growing districts of Hyderabad-Karnataka

Survey on seasonal incidence of insect pests and natural enemies in onion was undertaken in farmers field under protected conditions in four major onion growing districts *viz,* Raichur, Bellary, Yadgir and Gulbarga. In each district two talukas and from each taluk 4-6 villages and in each village two farmers field were selected based on extent of area cultivated as revealed from the data collected from Karnataka state department of agriculture (KSDA), Raichur. In Raichur district two talukas *viz.,* Raichur and Lingasugur were selected. Likewise, Sandur and Bellary taluka in Bellary district, Yadgir and Shahapur talukas in Yadgir district and Aland and Gulbarga talukas in Gulbarga district were selected for roving survey (Table 1).

In each field twenty plants were selected randomly and observations on number of thrips, leaf eating caterpillars and presence of other pests per plant was recorded. The defoliator larvae which were feeding on onion were brought to the lab and kept in the specimen tubes for emergence of natural enemies if any. Predatory population was also

Table 1. Location of roving survey conducted in north eastern dry zone of Karnataka during 2012-13

Sl. No.	District	Taluks	Villages
1.	Raichur	Raichur	Hosur, Kuknoor, Mamdapur, Nelahal, Gonal, Dinni.
		Lingasugur	Pamanakollur, Halabhavi, Argunt Cross, Ichanal, Santekellur.
2.	Yadgir	Yadgir	Hosalli, Balchakra, Hodagera, Dariyapur
		Shahapur	Gundapur, Tanda, Karadagi, Khanapur, Sagar, Gogi.
3.	Gulbarga	Gulbarga	Bannur, Aurad, Karadagi, Pala, Medakunda, Pattan.
		Aland	Bhodan, Belamji, Karahari, Kamalanagar.
4.	Bellary	Bellary	Kanekallu, Kollur, Kurap, Godal, Hagari, Somasamudra.
		Sandur	Bhujanganagar, Laxmipur, Krishanagar, Konapura.

counted simultaneously on same 20 plants which were selected for thrips and defoliator count.

Observation, were recorded approximately from one month after transplanting and continued at monthly interval upto harvesting of crop at all the locations. Natural enemies emerged out of defoliating larvae kept under observation were preserved in 80 per cent alcohol and sent for identification to NBAII (National Bureau of Agriculturally Important Insects), Bengaluru. Thrips specimen which were sent to Officer-in-Charge Centre for DNA Taxonomy, Molecular Systematics Division, Zoological Survey of India. M Block, New Alipore, Kolkata, West Bengal, for identification of different species were identified. During survey, the additional information on variety of seeds, date of sowing, stage of crop, management practice undertaken by the farmer and other information was collected from the farmers. Later monthly observations of each district was averaged and presented

3.2 Influence of dates of transplanting on the occurrence of insect pests of onion

A study on the influence of different dates of transplanting on the incidence of insect pests of onion was carried out at Main Agricultural Research Station, University of Agricultural Sciences, Raichur, Karnataka during 2012-13. Normally the farmers transplant onion in the second week of August, considering this in view the treatments comprising of different dates of sowing from July 15th to October 15th at an interval of 15 days was designed. Unsprayed delta N-53 variety of onion was maintained for this purpose. Onion variety (delta N-53) was sown in nursery according to treatments and later one month old seedlings were transplanted in the main field. In the main field no plant protection measures were undertaken and the other agronomic practices were commonly followed according to package of practices (Anon., 2011). A total of seven different dates of transplanting starting from July 15 to October 15 at fifteen days interval was undertaken. Crop was raised in completely randomized block design to know effect of planting dates on the peak incidence of pests with three replication. The crop was raised at a spacing of 30 x 15 cm with a plot size of 3 x 2 mts. Thrips population on onion transplanted at different times of growing season was recorded. From each plot around ten plants were selected randomly and observations were recorded on number of thrips, defoliators and natural enemies population at fifteen days intervals along with yield. Further, the data was subjected to statistical analysis. An attempt was also made to correlate the possible influence of weather parameters on population build up of onion insect pests.

3.3 Optimising plant protection schedule for insect pests of onion.

Only little information is available regarding evaluation of different chemicals against thrips and defoliators but no studies have been made with respect to optimisation of plant protection which is very much needed for farming community

For optimising the plant protection schedule, a field experiment was laid out in a Randomized Block Design (RBD) at Main Agricultural Research Station, Raichur during 2012-13 seasons with eight treatments including an untreated control with three replications. Different treatments designed were as follows.

T_1 - Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed and sowing in nursery and later such seedlings were transplanted and no plant protection was followed.

T_2 - Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed followed by one spray for sucking pest after 20-25 days after transplanting with fipronil 5 SC @ 1 ml/l.

T_3 - Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray with fipronil 5 SC @ 1 ml/l + one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.

T_4 - Seed treatment with imidachlopid 60 FS + two sprays with fipronil 5 SC @ 1 ml/l and thiamethoxam 25 WG @ 0.2 g/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.

T_5 - No seed treatment + one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l + one spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l

T_6 - No seed treatment, followed by one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two sprays with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.

T_7 - No seed treatment + no spray in nursery and two sprays with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.

T_8 - Untreated control.

These treatments were imposed when thrips and defoliators, *S. exigua* population reached ETL. Before imposing the treatments, pre-treatment observations were taken a day before application on five randomly selected plants. Post treatment observations were recorded on one, three, seven, ten and fifteen days after application.

Propiconazole @ 1 ml/l was sprayed as general fungicide for management of purple blotch to all the treatments. For Treatments number 1 to 4 seeds of onion were treated with imidacloprid 60 FS @ 9 ml/kg of seeds and sown in nursery. One month old seedlings were transplanted in the main field and first spray was under taken against sucking pests after 25 days after transplanting and second spray after 20 days of first spray defoliators as per the treatment based on ETL.

For treatment number T_5 and T_6 untreated seeds were sown in nursery and later sprayed with imidacloprid 17.8% SL and then one month old seedling were transplanted in the main field. Later the treatments were imposed as per the schedule for sucking pest and defoliators. In untreated control no spray was taken. Observations were recorded on number of thrips per plant and defoliator per plant and natural enemies 1 DBS, 1 DAS, 3 DAS, 5 DAS, 10 DAS and 15 DAS and later yield was recorded and subjected to statistical analysis.

EXPERIMENTAL RESULTS

IV. EXPERIMENTAL RESULTS

Investigations on the onion thrips, *Thrips tabaci* with reference to its survey, influence of dates of sowing and management was carried out at the Main Agricultural Research Station, University of Agricultural Sciences, Raichur during *kharif* 2012-13 and the results of the same are presented here under.

4.1 Survey for the incidence of insect pests and their natural enemies of onion in Hyderabad-Karnataka region

4.1.1 Survey on insect pests of onion

Survey was conducted in farmers fields of major onion growing district of Hyderabad-Karnataka *viz.*, Raichur (Lingasugur) Bellary (Sandur) Yadgir (Shahapur) Gulbarga (Aland) talukas from August 2012 to February 2013. The data collected on insect pests and natural enemies across the regions are presented below.

Onion thrips

4.1.1.1 Raichur

The population of onion thrips ranged from 10.42 to 20.00 thrips per plant in Raichur taluka (Table 2) wherein the highest population was recorded in the month of February (20.00 thrips/plant) and lowest population in the month of August (10.42 thrips/plant). In Lingasugur taluka the thrips population ranged from 10.32 to 16.75 thrips per plant with highest population was recorded in the month of February (16.75 thrips/plant) and lowest population in the month of November (10.32 thrips/plant). Between the two taluka highest thrips population was noticed in Raichur taluka. Over all mean of thrips population in Raichur district varied from 10.82 to 18.38 thrips per plant. The lowest incidence was recorded in the month of August and highest incidence was registered during February.

4.1.1.2 Gulbarga

The population of onion thrips ranged from 12.15 to 27.96 thrips per plant in Gulbarga taluka (Table 2) wherein, the lowest population was noticed in the month of August (12.15 thrips/plant) and highest population was recorded in the month of February (27.96 thrips/plant). In Aland taluka the thrips population varied from 17.00 to 25.57

thrips per plant with a highest population was recorded in the month of November (25.57 thrips/plant) and lowest population in the month of October (17.00 thrips/plant). Between the two taluka highest thrips population was noticed in Aland taluka. The overall mean of Gulbarga district, the thrips population varied from 15.1 to 25.77 thrips per plant, lowest incidence being recorded in the month of October and highest incidence was noticed during February.

4.1.1.3 Yadgir

Higher incidence of thrips was noticed throughout the cropping season in both the talukas of Yadgir districts. The population of onion thrips varied from 12.44 to 20.40 thrips per plant in Yadgir taluka (Table 2) wherein, the highest population was recorded in the month of February (20.40 thrips/plant) and lowest in the month of August (12.44 thrips/plant). In Shahapur taluka the thrips population ranged from 10.32 to 17.99 thrips per plant, highest was recorded in the month of October (17.99 thrips/plant) and lowest in the month of November (10.32 thrips/plant). Between the two taluka highest thrips population was recorded in Yadgir taluka. Overall mean of Yadgir district, the thrips incidence varied from 11.76 to 17.10 thrips per plant with minimum incidence was noticed in the month of November and the highest incidence was registered during February.

4.1.1.4 Bellary

The incidence of thrips was noticed throughout the cropping period in Bellary district also but the incidence was high in Sandur taluka compared to Bellary taluka. The population varied from 10.75 to 22.10 thrips per plant in Bellary taluka, (Table 2), wherein, the highest was recorded in the month of February (22.10 thrips/plant) and lower population in the month of August (10.75 thrips/plant). In Sandur taluka the thrips population ranged from 21.00 to 31.20 thrips per plant and highest population was recorded in the month of November (31.20 thrips/plant) and lowest population in the month of August (21.00 thrips/plant). The overall mean of Bellary district, revealed that the thrips varied from 15.88 to 26.10 per plant with lowest incidence being recorded in the month of August and the highest incidence was noticed during February (Plate 1).

The t-test has been done to know the interaction of the thrips population among the four district and result revealed significant difference among the districts. The average incidence of thrips from August to February was computed for each location and

Table 2. Incidence of *Thrips tabaci* on onion in different districts of Hyderabad-Karnataka region

Month	Number of thrips/plant*											
	Raichur			Gulbarga			Yadgir			Bellary		
	Raichur	Lingusugur	Mean	Gulbarga	Aland	Mean	Yadgir	Shahapur	Mean	Bellary	Sandur	Mean
August 2012	10.42	11.21	10.82	12.15	20.32	16.24	12.44	15.91	14.18	10.75	21.00	15.88
September 12	17.95	12.75	15.35	15.80	22.13	18.97	13.67	17.82	15.75	12.55	23.41	17.98
October 12	18.20	14.11	16.16	13.20	17.00	15.10	14.21	17.99	16.10	14.60	26.00	20.30
November 12	19.50	10.32	14.91	17.45	25.57	21.51	13.20	10.32	11.76	15.00	31.20	23.10
December 12	13.20	13.20	13.20	22.14	21.00	21.57	15.13	14.00	14.57	17.80	25.31	21.56
January 2013	15.25	14.55	14.90	24.00	18.23	21.12	17.50	12.75	15.13	20.98	27.70	24.34
February 13	20.00	16.75	18.38	27.96	23.58	25.77	20.40	13.80	17.10	22.10	30.11	26.11
Average	**17.35**	**13.27**	**14.82**	**18.96**	**21.12**	**20.04**	**15.22**	**14.66**	**14.94**	**16.25**	**26.39**	**21.32**

t-test Location	|t-value|	Significant/Non significant
Raichur-Gulbarga	3.20	S
Raichur-Yadgir	0.11	NS
Raichur-Bellary	4.01	S
Gulbarga-Yadgir	3.12	S
Gulbarga-Bellary	0.66	NS
Yadgir-Bellary	3.89	S

*Meanof20plants

Plate 1. Field view of *Thrips* damage in farmers field during survey

then compared using t-test. Significant difference was found in the incidence of thrips in Raichur between Gulbarga and Bellary district with a t-value of 3.20 and 4.01 respectively. Whereas, there was non significant difference in the thrips population between Raichur and Yadgir (t-value of 0.11). There was a significant difference in thrips population between Gulbarga and Yadgir (t-value of 3.12) whereas it was non significant with Bellary (t-value of 0.66). However, there was significant difference in thrips population noticed between Yadgir and Bellary (t-value of 3.89) districts.

The overall significant difference was found in all districts except between Raichur and Yadgir, Gulbarga and Bellary.

Defoliators

4.1.1.5 Raichur

The population of defoliators mainly *Spodoptera exigua* (Plate 2) varied from 0.40 to 2.30 larvae per plant in Raichur taluka (Table 3) in which the highest population being recorded in the month of August (2.30 larvae/plant) and lowest population in the month of November (0.40 larvae/plant). In Lingasugur taluka the defoliators population ranged from 0.50 to 2.50 larvae per plant, the highest population was noticed in the month of December (2.50 larvae/plant) and lowest population in the month of November (0.50 larvae/plant). Between the two taluka highest defoliators was noticed in Lingasugur taluka. Overall mean of Raichur district, the defoliators varied from 0.45 to 2.35 larvae per plant, the lowest incidence was recorded in the month of November and the highest was recorded during August.

4.1.1.6 Gulbarga

Incidence of defoliators was comparatively more in Aland taluka compared to Gulbarga taluka and the population ranged from 0.30 to 3.20 larvae per plant in Aland taluka, (Table 3) the highest population being recorded in the month of January (3.20 larvae/plant) and lower population in the month of November (0.30 larvae/plant). Over all mean of defoliators in Gulbarga district, varied from 0.25 to 2.25 larvae per plant, lowest incidence being recorded in the month of November and highest incidence being recorded during August.

4.1.1.7 Yadgir

The population of defoliators ranged from 0.90 to 3.00 larvae per plant in Yadgir taluka (Table 3), wherein the highest population was noticed in the month of September and January (3.00 larvae/plant) and lowest population in the month of February (0.90 larvae/plant). In Shahapur taluka the defoliators population varied from 0.50 to 3.20 larvae per plant with a highest was noticed in the month of August (3.20 larvae/plant) and the lowest in the month of November (0.50 larvae/plant). Between the two taluka highest defoliators population was recorded in Yadgir taluka. The Overall mean of Yadgir district, defoliators varied from 0.70 to 3.05 larvae per plant, incidence being lowest was recorded in the month of February and the highest incidence recorded during September.

4.1.1.8 Bellary

The population of defoliators mainly *S. exigua* ranged from 1.00 to 3.20 larvae per plant in Bellary taluka (Table 3), wherein the highest population was recorded in the month of August (3.20 larvae/plant) and the lowest in the month of October, November and February (1.00 larvae/plant). Whereas in Sandur taluka the defoliators population varied from 1.20 to 5.20 larvae per plant and highest was registered in the month of August (5.20 larvae/plant) and lowest population in the month of February (1.20 larvae/plant). Between the two taluka highest defoliators population was recorded in Sandur taluka. The overall mean of defoliators in Bellary district varied from of 1.10 to 4.20 in which lowest incidence was recorded in the month of February and highest incidence was registered during August month.

4.1.2 Survey on natural enemies

Spider

4.1.2.1 Raichur

The spider population (Plate 3) was found throughout the cropping season without much variation. The population of spiders ranged from 0.31 to 0.63 per plant in Raichur taluka (Table 4), with the maximum population registered in the month of August (0.63 spiders/plant) and lowest population in the month of February (0.31 spiders/plant) and in Lingasugur taluka the population of spiders ranged from 0.10 to 0.72 per plant with a highest population was recorded in the month of August (0.72 spiders/plant) and lower population in the month of December (0.10 spiders/plant). Between the two taluka highest spiders population was noticed in Raichur taluka. Over all mean of Raichur district revealed

Table 3. Incidence of defoliators on onion in four districts of Hyderabad-Karnataka region

Month	Number of larvae/plant*											
	Raichur			Gulbarga			Yadgir			Bellary		
	Raichur	Lingusugur	Mean	Gulbarga	Aland	Mean	Yadgir	Shahapur	Mean	Bellary	Sandur	Mean
August 2012	2.30	2.40	2.35	1.30	3.20	2.25	2.30	3.20	2.75	3.20	5.20	4.20
September 12	1.50	2.00	1.75	1.40	2.00	1.70	3.00	3.10	3.05	2.10	3.20	2.65
October 12	1.20	1.60	1.40	1.00	1.20	1.10	2.10	1.50	1.80	1.00	2.10	1.55
November 12	0.40	0.50	0.45	0.50	0.00	0.25	1.00	0.50	0.75	1.00	1.50	1.25
December 12	2.00	2.50	2.25	2.00	2.30	2.15	2.50	2.30	2.40	2.50	3.20	2.85
January 2013	1.00	1.20	1.10	1.00	2.50	1.75	3.00	1.70	2.35	1.70	2.40	2.05
February 13	1.00	1.00	1.00	0.70	0.80	0.75	0.90	0.50	0.70	1.00	1.20	1.10
Average	**1.18**	**1.60**	**1.47**	**1.13**	**1.71**	**1.42**	**2.11**	**1.83**	**1.97**	**1.79**	**2.69**	**2.24**

*Mean of 20 plan

Plate 2. Onion leaf damage caused by *S. exigua*

that the spider population varied from 0.30 to 0.68 per plant, lowest incidence was recorded in the month of January and highest incidence was registered during August.

4.1.2.2 Gulbarga

The population of spider ranged from 0.30 to 0.80 per plant in Gulbarga taluka (Table 4) the highest population was registered in the month of November (0.80 spiders/plant) and the lowest population in the month of October (0.30 spiders/plant). In Aland taluka the spider population ranged from 0.40 to 0.85 per plant, maximum population was recorded in the month of November (0.85 spiders/plant) and lowest population in the month of October and February (0.40 spiders/plant). Between the two taluka highest spiders population was noticed in Aland taluka. Over all mean of Gulbarga district, the spider population varied from 0.35 to 0.83 per plant, lowest incidence was registered in the month of October and highest incidence was recorded during November.

4.1.2.3 Yadgir

The spider population did not differ significantly between the two talukas of Yadgir districts and over all mean indicated that the spider population varied from 0.33 to 0.64 per plant (Table 4) the lowest population was registered in the month of February (0.33 spiders/plant) and highest population was recorded during August (0.64 spiders/plant).

4.1.2.4 Bellary

The spider population did not differ between the two talukas of Bellary districts. The population of spider (Table 4) was highest (0.50 spiders/plant) in the month of August and November and lowest in the months of October and January (0.30 spiders/plant). In Sandur taluka the spider population ranged from 0.30 to 0.75 per plant, highest population was noticed in the month of November (0.75 spiders/plant) and the lowest population in the months of September and February (0.30 spiders/plant). Between the two taluka highest spiders population was noticed in Sandur taluka. In Bellary district the spider population varied from 0.35 to 0.63 with a lowest incidence was recorded in the month of September and February and the highest incidence was recorded during November.

Table 4. Occurrence of spiders population on onion in four districts of Hyderabad-Karnataka region

Month	Number of spiders /plant*											
	Raichur			Gulbarga			Yadgir			Bellary		
	Raichur	Lingusugur	Mean	Gulbarga	Aland	Mean	Yadgir	Shahapur	Mean	Bellary	Sandur	Mean
August 2012	0.63	0.72	0.68	0.70	0.60	0.65	0.50	0.78	0.64	0.50	0.60	0.55
September 12	0.50	0.60	0.55	0.50	0.50	0.50	0.40	0.40	0.40	0.40	0.30	0.35
October 12	0.40	0.40	0.40	0.30	0.40	0.35	0.30	0.32	0.31	0.30	0.50	0.40
November 12	0.60	0.30	0.45	0.80	0.85	0.83	0.70	0.67	0.69	0.50	0.75	0.63
December 12	0.60	0.10	0.35	0.70	0.75	0.73	0.60	0.65	0.63	0.40	0.69	0.55
January 2013	0.40	0.20	0.30	0.50	0.56	0.53	0.62	0.56	0.59	0.30	0.56	0.43
February 13	0.31	0.40	0.36	0.40	0.40	0.40	0.30	0.35	0.33	0.40	0.30	0.35
Average	**0.47**	**0.39**	**0.44**	**0.56**	**0.58**	**0.57**	**0.49**	**0.53**	**0.51**	**0.40**	**0.53**	**0.47**

* Mean of 20 plants

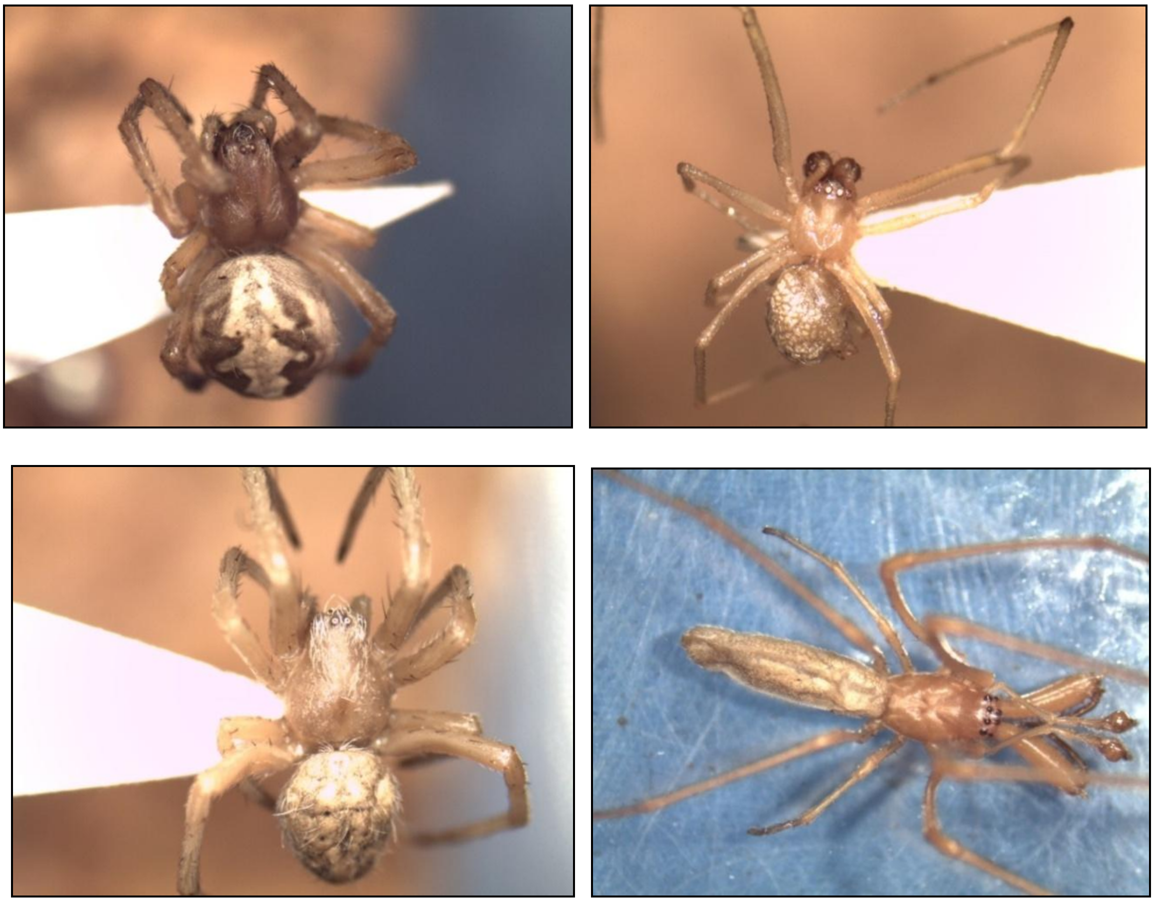


Plate 3. Spider population noticed during survey in onion field

Coccinellids

4.1.2.5 Raichur

The population of coccinellid, *Coccinella transversalis* (Plate 4) ranged from 0.20 to 0.30 per plant in Raichur taluka (Table 5) and the maximum population was registered in the month of October (0.30 coccinellids/plant) and lowest population in the month of November and February (0.20 coccinellids/plant). In Lingasugur taluka the coccinellid population ranged from 0.20 to 0.30 per plant wherein maximum population was recorded in the month of November (0.30 coccinellids/plant) and the lowest population in the month of December (0.20 coccinellids/plant). Between the two taluka highest coccinellids population was noticed in Lingasugur taluka. Overall mean of Raichur district, the coccinellids varied from of 0.22 to 0.29 per plant lowest incidence was registered in the month of September and maximum population was recorded during October.

4.1.2.6 Gulbarga

The coccinellid mainly *Coccinella transversalis* population varied from 0.10 to 0.35 per plant in Gulbarga taluka (Table 5) wherein, the highest population was recorded in the month of November (0.35 coccinellids/plant) and lowest population in the month of February (0.10 coccinellids/plant). In Aland taluka, the coccinellids population ranged from 0.22 to 0.35 per plant with a maximum population was registered in the month of October (0.35 coccinellids/plant) and the lowest population in the month of January (0.22 coccinellids/plant). Between the two taluka highest coccinellids population was registered in Aland taluka. In Gulbarga district the coccinellids varied from of 0.19 to 0.33 per plant with a lowest population was recorded in the month of January and February and highest incidence was noticed during October and November months.

4.1.2.7 Yadgir

The coccinellid, *Coccinella transversalis* population ranged from 0.10 to 0.26 per plant in Yadgir taluka (Table 5), with a maximum population was registered in the month of November (0.26 coccinellids/plant) and the lowest population in the month of January (0.10 coccinellids/plant). In Shahapur taluka the coccinellids population ranged from 0.15 to 0.32 per plant with a maximum population was registered in the month of February (0.32 coccinellids/plant) and the lowest population in the month of October (0.15 coccinellids/plant). Between the two taluka highest coccinellids population was noticed in Shahapur taluka. Overall mean of Yadgir district, the coccinellid population varied from 0.18

to 0.28 per plant with a lowest population was registered in the month of October and January and the highest population was recorded during November.

4.1.2.8 Bellary

The coccinellid population ranged from 0.10 to 0.22 per plant in Bellary taluka (Table 5) with a highest population was registered in the month of February (0.22 coccinellids/plant) and lowest population in the month of September and October (0.10 coccinellids/plant). In Sandur taluka the coccinellids varied from 0.24 to 0.36 per plant, highest population was recorded in the month of November (0.36 coccinellids/ plant) and lowest population in the month of February (0.24 coccinellids/plant). Between the two taluka highest coccinellids population was noticed in Sandur taluka. In Bellary district the overall coccinellid varied from of 0.19 to 0.27 per plant, lowest incidence was recorded in the month of September and highest incidence was recorded during October and November months.

4.2 Influence of different dates of transplanting of onion on the incidence of insect pests

Result obtained on the incidence of insect pests and natural enemies from different dates of transplanting are presented in the table bearing number from 6 to 10.

4.2.1 Impact of transplanting dates of onion on the incidence of *Thrips tabaci*

15 Days after transplanting

The population of thrips registered at first time *i.e.*, 15 days after transplanting varied from 4.0 to 14.33 per plant in which the lowest incidence of (4.00/ plant) thrips was registered in October 15th transplanted crop followed by August 30th transplanted (5.55 thrips/plant) (Table 6). July 15th, September 15th and September 30th transplantings recorded the thrips population of 8.54, 7.20 and 6.15 per plant respectively. The highest population of 14.33 thrips per plant was recorded in July 30th transplanted condition (Plate 5).

30 Days after transplanting

Thirty days after transplanting the infestation of thrips was significantly lower in September 30th transplanted situation (5.07 thrips/plant) followed by October 15th, August 30th and September 15th (6.00, 8.00 and 8.93 thrips/plant) transplanted situation which were on par with each other. However, July 30th and August 15th transplanted onion crops recorded

Table 5. Occurrence of coccinellids population on onion in four districts of Hyderabad-Karnataka region.

Month	Number of coccinellids/plant*											
	Raichur			Gulbarga			Yadgir			Bellary		
	Raichur	Lingusugur	Mean	Gulbarga	Aland	Mean	Yadgir	Shahapur	Mean	Bellary	Sandur	Mean
August 2012	0.23	0.26	0.25	0.23	0.26	0.25	0.15	0.24	0.20	0.15	0.26	0.21
September 12	0.20	0.24	0.22	0.25	0.30	0.28	0.18	0.20	0.19	0.10	0.28	0.19
October 12	0.30	0.28	0.29	0.30	0.35	0.33	0.20	0.15	0.18	0.10	0.30	0.20
November 12	0.20	0.30	0.25	0.35	0.30	0.33	0.26	0.30	0.28	0.18	0.36	0.27
December 12	0.26	0.20	0.23	0.20	0.32	0.26	0.15	0.28	0.22	0.16	0.25	0.21
January 2013	0.24	0.22	0.23	0.15	0.22	0.19	0.10	0.25	0.18	0.14	0.30	0.22
February 13	0.20	0.26	0.23	0.10	0.28	0.19	0.18	0.32	0.25	0.22	0.24	0.23
Average	**0.23**	**0.25**	**0.24**	**0.23**	**0.29**	**0.26**	**0.17**	**0.25**	**0.21**	**0.15**	**0.28**	**0.22**

* Mean of 20 plants

Plate 4. ***Coccinella transversalis*** **recorded from onion ecosystem.**

the thrips population of 13.00 and 15.13 thrips per plant and were on par with each another. The population of thrips were significantly highest in July 15th transplanted onion (16.67 thrips/plant).

45 Days after transplanting

There was an overall increase in population of thrips after 45 days after transplanting in all the treatments with increase in age of crops but October 15th, August 30th, September 15th and September 30th transplanted onion recorded significantly lowest thrips population of 12.07, 13.00, 14.00 and 14.33 thrips per plant respectively and were on par with each other. July 30th, July 15th and August 15th transplanted onion recorded highest population of 15.50, 17.17 and 20.00, thrips/plant respectively.

60 Days after transplanting

Incidence of thrips at sixty days after transplanting were found to be minimum in August 30th, October 15th, August 15th and September 15th transplanted conditions (16.10, 17.00, 18.00 and 18.10 thrips/plant respectively) and were on par with each other. July 30th transplanted onion was prove to severe infestation by recording highest thrips population of 30.33 thrips per plant.

75 Days after transplanting

After seventy five days of transplanting October 15th and September 30th transplanted onion proved to be the best dates of transplanting which recorded significantly lowest thrips population of 21.03 and 23.10 thrips per plant respectively followed by August 30th transplanted condition (26.08 thrips/plant). July 15th, August 15th, July 30th and September 15th transplantings recorded 27.50, 28.00, 28.10 and 30.00 thrips per plant respectively and all these were on par with each other depicting their inferiority as they recorded more thrips population.

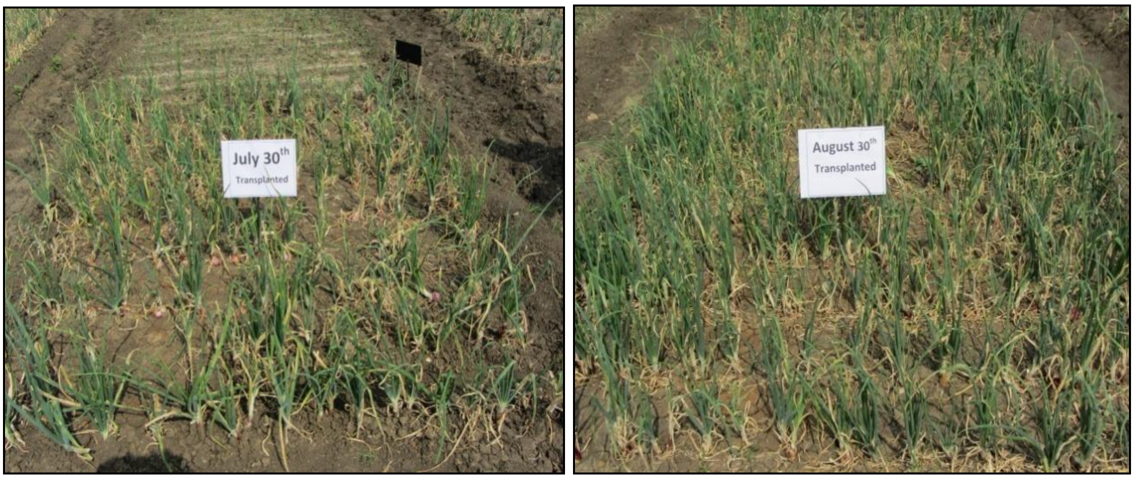
90 Days after transplanting

There was an overall increase in population of thrips after 90 days of transplanting in all the treatment but October 15th, September 30th and July 30th transplanted onion recorded significantly lower thrips population of 20.10, 21.67 and 22.00 thrips per plant respectively. The next best dates were September 15th, August 30th and August 15th transplanting 32.15, 34.33 and 36.00 thrips per plant respectively. These were on par with each other. Highest incidence of 37.67 thrips per plant was noticed in July 15th transplanted crop.

Table 6. Influence of different dates of transplanting of onion on the incidence of *Thrips tabaci*

Dates of Transplantings	Number of thrips /plant at different days of transplanting						Yield (kg/ plot)	Yield (t/ha)
	15	30	45	60	75	90		
T_1: July 15th 2012	8.54 (3.01)^{c}	16.67 (4.14)^{cd}	17.17 (4.20)^{ab}	22.00 (4.74)^{b}	27.50 (5.28)c	37.67 (6.17)^{bc}	7.37^{d}	12.27
T_2: July 30th 2012	14.33 (3.85)^{d}	13.00 (3.67)^{c}	15.50 (4.00)^{ab}	30.33 (5.55)c	28.10 (5.35)c	22.00 (4.74)^{a}	7.55^{d}	12.57
T_3: August 15th 2012	8.10 (2.93)^{c}	15.13 (3.95)c	20.00 (4.53)^{abc}	18.00 (4.30)a	28.00 (5.34)^{c}	36.00 (6.04)^{b}	7.48^{d}	12.47
T_4: August 30th 2012	5.55 (2.46)^{b}	8.00 (2.90)^{ab}	13.00 (3.67)a	16.10 (4.07)^{a}	26.08 (5.16)^{b}	34.33 (5.90)^{b}	7.57^{d}	12.61
T_5: September 15th 2012	7.20 (2.77)^{c}	8.93 (3.07)^{ab}	14.00 (3.81)^{a}	18.10 (4.30)^{a}	30.00 (5.52)^{c}	32.15 (5.70)^{b}	8.92^{c}	14.86
T_6: September 30th 2012	6.15 (2.58)^{c}	5.07 (2.33)a	14.33 (3.85)^{a}	22.33 (4.78)b	23.10 (4.85)^{a}	21.67 (4.70)^{a}	9.40^{b}	15.66
T_7: October 15th 2012	4.00 (2.11)a	6.00 (2.55)a	12.07 (3.53)a	17.00 (4.16)a	21.03 (4.64)a	20.10 (4.54)a	10.07^{a}	16.77
S.Em±	**0.08**	**0.11**	**0.11**	**0.13**	**0.13**	**0.13**	**0.08**	**0.08**
CD @ 5%	**0.25**	**0.35**	**0.34**	**0.40**	**0.40**	**0.39**	**0.26**	**0.26**
CV (%)	**9.49**	**9.56**	**9.28**	**9.76**	**8.69**	**8.84**	**10.11**	**10.11**

Mean followed by the same letter in a column do not differ significantly.
Figures in parentheses are $\sqrt{x+0.5}$ transformed values.



More thrips incidence in early planted situation

Less thrips incidence in late planted situation

Plate 5. Influence of dates of transplanting of onion on thrips incidence.

4.2.1.1 Correlation of incidence of thrips with weather parameters

Different dates of transplantings were subjected for correlation analysis to find out the relationship between thrips population and weather parameters such as maximum temperature, minimum temperature and rainfall recorded at MARS, Raichur.

The thrips population were positively correlated with maximum temperature and negatively correlated with minimum temperature and rainfall which indicated that higher temperature favours the development of thrips while high rainfall was found to be detrimental to thrips (Table 7).

4.2.2 Influence of Transplanting dates of onion on incidence of defoliators.

15 Days after transplanting

Defoliator population mainly *Spodoptera exigua* ranged from zero to 0.53 per plant at 15 days after transplanting (Table 8), in which July 15th transplanted onion registered no incidence of defoliators and was significantly superior to all other treatments. This was followed by September 30th and October 15th which recorded 0.10 and 0.12 defoliator per plant respectively and were on par with each other. While, August 30th transplanted onion recorded highest population of 0.53 defoliator per plant, which was on par with August 15th and September 15th (0.50 and 0.47 larvae/plant respectively).

30 Days after transplanting

Thirty days after transplanting, September 30th and October 15th transplantation were found to be superior by recording least number of 0.15 and 0.20 larvae per plant respectively. Contrarily significantly highest population was found in August 15th and August 30th (0.53 and 0.55 defoliator/ plant respectively) and were par with each other.

45 Days after transplanting

Even at 45 days after transplanting, October 15th was found to be superior by recording a least population of 0.26 defoliator per plant followed by September 30th with a population of 0.50 larvae per plant. The infestation by defoliators was highest in August 30th transplantation (1.00 larvae/plant) which was on par with July 30th (0.93 larvae/plant).

Table 7. Correlation of different dates of transplanting on onion thrips with weather parameters

Dates of transplanting	Correlation Value			Mean No. of thrips/plant
	Maximum Temperature (^oC)	Minimum Temperature (^oC)	Rain Fall (mm)	
T_1: July 15th 2012	0.132	-0.963	-0.215	21.59
T_2: July 30th 2012	0.012	-0.684	-0.106	20.54
T_3: August 15th 2012	0.075	-0.846	-0.727	20.87
T_4: August 30th 2012	0.215	-0.838	-0.710	17.18
T_5: September 15th 2012	0.004	-0.900	-0.856	18.36
T_6: September 30th 2012	0.352	-0.762	-0.886	15.44
T_7: October 15th 2012	0.403	-0.016	-0.635	13.37

60 Days after transplanting

After 60 days of transplanting October 15th was found to be superior by recording lowest population of 0.30 larvae per plant, followed by August 15th, September 30th and September 15th which on par with each other with a population of (0.46, 0.56 and 0.60 larvae/plant respectively). Highest population was found in July 30th, July 15th and August 30th which recorded 0.73, 0.83 and 0.84 defoliator per plant respectively and were on par with each other.

75 Days after transplanting

Defoliator population after 75 days after transplanting was very low in October 15th (0.52 larvae/plant) followed by September 30th and August 15th (0.80 and 0.92 defoliator/ plant respectively). The infestation of defoliators was highest (1.53 larvae/ plant) in July 30th transplanted onion.

90 Days after transplanting

Observation recorded on defoliators at 90 days after transplanting revealed that October 15th and September 30th transplanting have given best results by recording 0.47 and 0.54 defoliators per plant were on par with all other treatments.

4.2.3 Influence of transplanting dates of onion on incidence of spiders

15 days after transplanting

In the beginning of fifteen days after transplanting there was no significant difference in the spider population was noticed among different dates of transplantings (Table 9). However, August 15th and August 30th were found to be superior as they registered more population of 0.41 and 0.34 and were on par with July 30th and September 15th, treatments October 15th, September 30th and July 15th recorded least spider population of 0.17, 0.20 and 0.20 spiders per plant respectively.

30 Days after transplanting

At 30 days after transplanting also all the treatments were on par with each other where in the spider population ranged from 0.28 to 0.40 per plant.

45 Days after transplanting

Observation registered at 45 days after transplanting showed similar trend as above.

Table 8. Influence of different dates of transplanting on defoliators population

Dates of transplantings	Number of defoliators/plant at different days of transplanting					
	15	**30**	**45**	**60**	**75**	**90**
T_1: July 15th 2012	0.00 (0.71)a	0.46 (0.98)^{b}	0.73 (1.11)c	0.83 (1.15)d	1.07 (1.25)bc	0.67 (1.08)^{ab}
T_2: July 30th 2012	0.20 (0.84)c	0.47 (0.98)b	0.93 (1.19)^{cd}	0.73 (1.11)d	1.53 (1.42)^{bcde}	0.73 (1.11)^{abc}
T_3: August 15th 2012	0.50 (1.00)d	0.53 (1.02)c	0.80 (1.14)c	0.46 (0.98)b	0.92 (1.19)b	0.80 (1.14)^{abc}
T_4: August 30th 2012	0.53 (1.02)de	0.55 (1.02)c	1.00 (1.22)^{cde}	0.84 (1.16)d	1.30 (1.34)^{bcd}	0.67 (1.08)^{ab}
T_5: September 15th 2012	0.47 (0.98)d	0.42 (0.96)b	0.85 (1.16)c	0.60 (1.05)bc	1.03 (1.24)b^{c}	0.90 (1.18)^{abcd}
T_6: September 30th 2012	0.10 (0.77)b	0.15 (0.81)a	0.50 (1.00)b	0.56 (1.03)b	0.80 (1.14)b	0.54 (1.02)a
T_7: October 15th 2012	0.12 (0.79)b	0.20 (0.84)a	0.26 (0.87)a	0.30 (0.89)a	0.52 (1.01)a	0.47 (0.98)a
S.Em±	**0.01**	**0.01**	**0.02**	**0.02**	**0.03**	**0.02**
CD @ 5%	**0.03**	**0.03**	**0.05**	**0.05**	**0.09**	**0.06**
CV (%)	**12.15**	**9.43**	**8.80**	**9.51**	**13.49**	**9.92**

Mean followed by the same letter in a column do not differ significantly.
Figures in parentheses are $\sqrt{x+0.5}$ transformed values.

60 Days after transplanting

At 60 days after transplanting October 15th and September 30th recorded highest number of spiders of 1.08 and 1.14 spiders per plant respectively. The population of spiders was lowest in July transplanted onion.

75 Days after transplanting

Again after seventy five days of transplanting the trend continued as in 60 days of transplanting with September 30th and October 15th recording 1.53 and 1.73 spiders per plant respectively and this was followed by September 15th recorded 1.21 spiders per plant. July 15th and July 30th which recorded lowest population of spiders (0.41 and 0.57 spiders/plant respectively).

90 Days after transplanting

After ninety days of transplanting population increased and ranged between 0.60 to 1.37 spiders per plant. All the treatments are on par with each other.

4.2.4 Influence of transplanting dates of onion on incidence of coccinellids

15 Days after transplanting

The population of coccinellids varied significantly after 15 days of transplanting in onion transplanted at different dates (Table 10) July 30th, August 15th and September 30th transplanted onion recorded significantly highest population of 0.12, 0.12 and 0.13 coccinellids/plant respectively and were on par with each other followed by July 15th and October 15th (0.10 coccinellids/plant each) transplanted onion. Lowest number of coccinellids were found in September 15th (0.08 Coccinellids/plant).

30 Days after transplanting

After thirty days of transplanting significantly highest population of coccinellids were observed on September 30th, October15th, and July 30th (0.17, 0.16 and 0.14 coccinellids/plant respectively) and were on par with each other followed by both July 15th, August 30th and August 15th transplanted where in population ranged between 0.12 to 0.13 coccinellids per plant and were on par with each other. September 15th registered lowest coccinellids population of 0.10 coccinellids per plant.

Table 9. Influence of different dates of transplanting on spider population

Dates of transplantings	Number of spiders /plant at different days of transplanting					
	15	**30**	**45**	**60**	**75**	**90**
T_1: July 15^{th} 2012	0.20 (0.84)c	0.28 (0.88)ab	0.31 $(0.90)^{abc}$	0.35 $(0.92)^{d}$	0.41 $(0.95)^{cde}$	0.60 $(1.05)^{abc}$
T_2: July 30^{th} 2012	0.30 (0.89)ab	0.38 (0.94)a	0.33 $(0.91)^{abc}$	0.41 (0.95)d	0.57 (1.02)cd	0.67 $(1.08)^{abc}$
T_3: August 15^{th} 2012	0.41 (0.95)a	0.40 (0.95)a	0.43 (0.97)a	0.54 (1.02)c	0.75 (1.12)c	0.77 (1.13)ab
T_4: August 30^{th} 2012	0.34 (0.92)a	0.30 $(0.89)^{ab}$	0.36 $(0.93)^{ab}$	0.61 (1.05)c	0.82 (1.15)c	0.60 $(1.05)^{abc}$
T_5: September 15^{th} 2012	0.30 (0.89)ab	0.37 (0.93)a	0.45 (0.97)a	0.95 $(1.20)^{ab}$	1.21 (1.31)b	1.03 $(1.24)^{ab}$
T_6: September 30^{th} 2012	0.20 (0.84)c	0.35 (0.92)a	0.53 (1.02)a	1.14 (1.28)a	1.53 (1.43)a	1.37 (1.37)a
T_7: October 15^{th} 2012	0.17 (0.82)c	0.31 $(0.90)^{ab}$	0.51 (1.00)a	1.08 (1.25)a	1.73 (1.49)a	1.17 (1.29)a
S.Em±	**0.01**	**0.01**	**0.02**	**0.02**	**0.04**	**0.03**
CD @ 5%	**0.03**	**0.04**	**0.05**	**0.05**	**0.11**	**0.11**
CV (%)	**10.06**	**10.72**	**13.39**	**9.67**	**12.16**	**14.54**

Mean followed by the same letter in a column do not differ significantly.
Figures in parentheses are $\sqrt{x+0.5}$ transformed values.

45 Days after transplanting

After forty five days of transplanting significantly highest population of coccinellids were noticed on October 15th and September 30th transplantings (0.30 and 0.28 coccinellids/plant respectively) which were on par with each other. Population of coccinellids ranged from 0.20 to 0.16 per plant in other treatment which were on par with each other and July 15th and August 15th which recorded low coccinellids population of 0.16 and 0.14 per plant respectively.

60 Days after transplanting

After sixty days of transplanting significantly highest population of coccinellids were noticed on October 15th and September 30th (0.37 and 0.34 coccinellids/plant respectively) which were on par with each other. This was followed by September 15th, August 30th, July 30th and July 15th wherein population of coccinellids ranged from 0.26 to 0.22 per plant respectively and all these were on par with each other. August 15th transplanting registered low coccinellids population of 0.18 per plant.

75 Days after transplanting

After seventy five days of transplanting significantly highest population of coccinellids were recorded on October 15th and September 30th (0.48 and 0.42 coccinellids/plant respectively) which were on par with each other. This was followed by September 15th, August 30th, July 15th and July 30th wherein population of coccinellids ranged from 0.48 to 0.30 per plant respectively and these all were on par with each other, August 15th recorded lower coccinellids population of 0.18 per plant.

90 Days after transplanting

After ninety days of transplanting significantly highest population of coccinellids were registered on October 15th and September 30th (0.61 and 0.52 coccinellids/plant respectively) which were on par with each. These were followed by September 15th, August 30th, July 15th and July 30th where in population of coccinellids ranged from 0.42 to 0.34 per plant were on par with each other. However, August 15th which recorded less population of 0.28 coccinellids per plant.

4.2.4.1 Yield

Maximum onion yield of 16.77 t/ha was obtained from treatment which was transplanted on October 15th followed by September 30th (15.66 t/ ha). Significantly lowest

Table 10. Influence of different dates of transplanting on coccinellids population

Dates of transplantings	Number of coccinellids /plant at different days of transplanting					
	15	**30**	**45**	**60**	**75**	**90**
T_1: July 15^{th} 2012	0.10 (0.77)b	0.12 (0.79)b	0.16 (0.81)bc	0.22 (0.85)b	0.32 $(0.91)^{abc}$	0.36 (0.93)b
T_2: July 30^{th} 2012	0.12 (0.79)a	0.14 (0.80)a	0.18 (0.82)b	0.24 (0.86)b	0.30 $(0.89)^{abc}$	0.34 (0.92)b
T_3: August 15^{th} 2012	0.12 (0.79)a	0.13 (0.79)b	0.14 (0.80)bc	0.18 (0.82)c	0.25 $(0.86)^{abcd}$	0.28 $(0.88)^{bc}$
T_4: August 30^{th} 2012	0.10 (0.77)b	0.12 (0.79)b	0.17 (0.82)b	0.23 (0.85)b	0.32 $(0.91)^{abc}$	0.36 (0.93)b
T_5: September 15^{th} 2012	0.08 (0.76)bc	0.10 (0.77)bc	0.20 (0.84)b	0.26 (0.87)b	0.35 $(0.92)^{ab}$	0.42 (0.96)b
T_6: September 30^{th} 2012	0.13 (0.79)a	0.17 (0.82)a	0.28 (0.88)a	0.34 (0.92)a	0.42 $(0.96)^{a}$	0.52 (1.01)a
T_7: October 15^{th} 2012	0.10 (0.77)b	0.16 (0.81)a	0.30 (0.89)a	0.37 (0.93)a	0.48 $(0.99)^{a}$	0.61 (1.05)a
S.Em±	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
CD @ 5%	**0.02**	**0.02**	**0.02**	**0.02**	**0.04**	**0.04**
CV (%)	**13.72**	**10.96**	**9.16**	**9.42**	**10.61**	**10.07**

Mean followed by the same letter in a column do not differ significantly.
Figures in parentheses are $\sqrt{x+0.5}$ transformed values.

yield was obtained in July 15th transplanted onion which was on par with July 30th, August 15th and 30th transplantation (Table 6).

4.3 Optimization of plant protection schedule for management of insect pests of onion

Results of the experiment on evaluation of plant protection schedule are narrated in detail here under.

4.3.1 Management of onion thrips

First Spray

One day before spray

Observations made on thrips population a day before spraying indicated that all the treatments including untreated control recorded population ranging from 12.20 to 20.67 thrips per plant (Table 11). Least number of thrips was recorded in seed treatment with imidacloprid 60 FS @ 9 ml/l which was found to superior to all other treatments and was on par with T_2 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray of fipronil 5 SC @ 1 ml/l.), T_3 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray with fipronil 5 SC @ 1 ml/l + one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.) and T_4 (seed treatment with imidachlopid 60 FS + two sprays with fipronil 5 SC @ 1 ml/l and thiamethoxam 25 WG @ 0.2 g/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l) which recorded 12.33, 12.30 and 12.47 thrips per plant respectively (Plate 6). These were followed by T_6 (no seed treatment, followed by one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two sprays with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one sprays with chlorantraniliprole 18.5 SC @ 0.15 ml/l), which recorded 15.27 thrips per plant and was on par with T_5 (no seed treatment + one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l + one spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l) which recorded (15.40 thrips/plant). Thrips population was significantly higher in T_7 (no seed treatment + no spray in nursery and two sprays with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l) which recorded 19.83 thrips per plant which was on par with T_8 (untreated control) with a thrips population of 20.67 per plant (Plate 6 and plate 7).

One day after spray

One day after spray, the number of thrips ranged from 3.00 to 21.37 per plant in different treatment. Significantly lowest number of thrips was noticed in T_4 (Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two sprays with thiamethoxam 25 WG @ 0.2 g/l + fipronil 5 SC @ 1 ml/l and one spray of chlorantraniliprole 18.5 SC @ 0.15 ml/l) followed by T_6 (no seed treatment, one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two spray with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one sprays with chlorantraniliprole 18.5 SC @ 0.15 ml/l) which recorded 5.53 thrips per plant. The treatments T_3 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray with fipronil 5 SC @ 1 ml/l + one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.), T_2 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray of fipronil 5 SC @ 1 ml/l.) and T_5 (no seed treatment + one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l + one spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l) recorded 6.33, 6.83 and 7.90 thrips per plant respectively and were on par with each other. Maximum number of (21.37 thrips/ plant) were found in T_8 (untreated control)

Three days after spray

Three days after spray there was a significant variation in thrips between the treatments and the number of thrips per plant ranged between 1.41 and 24.33 per plant. Significantly lowest number of 1.41 thrips per plant was recorded in T_4 (seed treatment with imidachlopid 60 FS + two sprays with fipronil 5 SC @ 1 ml/l and thiamethoxam 25 WG @ 0.2 g/l and one sprays with chlorantraniliprole 18.5 SC @ 0.15 ml/l) followed by T_6 (no seed treatment, followed by one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two sprays with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one sprays with chlorantraniliprole 18.5 SC @ 0.15 ml/l) where in 2.73 thrips per plant was recorded. The treatment like T_3 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray with fipronil 5 SC @ 1 ml/l + one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.), T_2 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray of fipronil 5 SC @ 1 ml/l.), T_5 (no seed treatment + one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l + one spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l) and T_7 (no seed treatment + no spray in nursery and two sprays with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l) recorded 4.08, 4.67, 6.11 and 7.90 thrips per plant respectively and they significantly differed from each other. Untreated control proved to be significantly inferior by recording highest population of (24.33 thrips/plant), followed by (17.33 thrips/plant) where in seed treatment was followed without spray.

Five days after spray

Five days after spray, the number of thrips per plant varied between 0.90 and 27.00 in different treatments. Significantly least number of 0.90 thrips per plant was recorded in T_4 (Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two sprays with thiamethoxam 25 WG @ 0.2 g/l + fipronil 5 SC @ 1 ml/l and one spray of chlorantraniliprole 18.5 SC @ 0.15 ml/l) which proved superior followed by T_6 (no seed treatment, followed by one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two sprays with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l) which recorded 1.58 thrips per plant. The next best treatments was T_3 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray with fipronil 5 SC @ 1 ml/l + one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.) (2.51 thrips per plant) which was on par with T_2 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray of fipronil 5 SC @ 1 ml/l.) (2.73 thrips/ plant) and treatment like T_5 (no seed treatment + one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l + one spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l) and T_7 (no seed treatment + no spray in nursery and two sprays with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l) thrips population of 4.08 and 5.04 per plant was recorded and these differ significantly from each other. Treatment T_8 (untreated control) proved to be inferior by recording population of 27.00 thrips per plant followed by T_1 only seed treatment without spray which registered 19.17 thrips per plant.

Ten days after spray

Ten days after spray, the number of thrips per plant ranged from 0.78 to 29.43 in different treatments. T_4 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two sprays with thiamethoxam 25 WG @ 0.2 g/l + fipronil 5 SC @ 1 ml/l and one spray of chlorantraniliprole 18.5 SC @ 0.15 ml/l) treatment continued to be superior by recording lowest number (0.78 thrips/plant) and was on par with T_6 (no seed treatment, followed by one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two sprays with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one sprays with chlorantraniliprole 18.5 SC @ 0.15 ml/l) which recorded (1.17 thrips /plant). These were followed by T_3 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray with fipronil 5 SC @ 1 ml/l + one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.) and T_2 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray of fipronil 5 SC @ 1 ml/l.) which recorded 2.00 and 2.20 thrips per plant and were on par with each other. T_8 (untreated control) recorded highest population of 29.43 thrips per plant followed by T_1 in where 23.04 thrips per plant were present.

Fifteen days after spray

Fifteen days after spray the number of thrips per plant ranged from 0.92 to 33.33 in different treatments. Least number of thrips was noticed in T_4 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two sprays with thiamethoxam 25 WG @ 0.2 g/l + fipronil 5 SC @ 1 ml/l and one spray of chlorantraniliprole 18.5 SC @ 0.15 ml/l) (0.92 thrips/plant) and T_6 (no seed treatment, followed by one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two sprays with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one sprays with chlorantraniliprole 18.5 SC @ 0.15 ml/l) (1.32 thrips /plant) which were on par with each other. The next best treatments were T_3 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray with fipronil 5 SC @ 1 ml/l + one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.) and T_2 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray of fipronil 5 SC @ 1 ml/l.) which recorded 2.13 and 2.31 thrips per plant which were on par with each other. T_8 (untreated control) recorded highest population of 33.33 thrips per plant followed by T_1 (seed treatment with imidacloprid 60 FS @ 9 ml/l) which recorded 27.54 thrips per plant.

Second Spray

One day before spray

Day before spraying thrips population ranged from 10.17 to 19.33 thrips per plant (Table 12). Treatment T_4 (Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two sprays with thiamethoxam 25 WG @ 0.2 g/l + fipronil 5 SC @ 1 ml/l and one spray of chlorantraniliprole 18.5 SC @ 0.15 ml/l) was found to be superior over all other treatments by recording a least number of population of 10.17 thrips per plant. This was followed by T_6 (no seed treatment, followed by one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two sprays with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one sprays with chlorantraniliprole 18.5 SC @ 0.15 ml/l) which recorded 11.33 thrips per plant but was on par with T_3 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray with fipronil 5 SC @ 1 ml/l + one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.) and

Table 11. Optimization of plant protection schedule for the management of *Thrips tabaci* on onion (first spray)

Treatment details	Thrips/plant					
	1 DBS	**1 DAS**	**3 DAS**	**5 DAS**	**10 DAS**	**15 DAS**
T_1: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed.	12.20 (3.56)[a]	14.03 (3.81)[ef]	17.33 (4.22)[g]	19.17 (4.43)[g]	23.04 (4.85)[f]	27.54 (5.30)[g]
T_2: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray of fipronil 5 SC @ 1 ml/l.	12.33 (3.58)[ab]	6.83 (2.71)[bcd]	4.67 (2.27)[d]	2.73 (1.80)[cd]	2.20 (1.64)[bc]	2.31 (1.68)[cd]
T_3: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray with fipronil 5 SC @ 1 ml/l + one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.	12.30 (3.58)[ab]	6.33 (2.61)[bc]	4.08 (2.14)[c]	2.51 (1.73)[c]	2.00 (1.56)[b]	2.13 (1.62)[c]
T_4: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two spray with fipronil 5 SC @ 1 ml/l + thiamethoxam 25 WG @ 0.2 g/l and one spray of chlorantraniliprole 18.5 SC @ 0.15 ml/l.	12.47 (3.60)[abc]	3.00 (1.86)[a]	1.41 (1.38)[a]	0.90 (1.18)[a]	0.78 (1.13)[a]	0.92 (1.19)[a]
T_5: No seed treatment + one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l + one spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l	15.40 (3.99)[de]	7.90 (2.90)[d]	6.11 (2.57)[e]	4.08 (2.14)[e]	3.21 (1.93)[d]	3.30 (1.95)[e]
T_6: No seed treatment, one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two spray with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.	15.27 (3.97)[d]	5.53 (2.45)[b]	2.73 (1.80)[b]	1.58 (1.44)[b]	1.17 (1.29)[ab]	1.32 (1.35)[ab]
T_7: No seed treatment + no spray in nursery and two spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.	19.83 (4.51)[f]	12.00 (3.53)[e]	7.90 (2.90)[f]	5.04 (2.35)[f]	4.10 (2.14)[de]	4.18 (2.16)[f]
T_8: Untreated control.	20.67 (4.59)[fg]	21.37 (4.68)[g]	24.33 (4.98)[h]	27.00 (5.24)[h]	29.43 (5.47)[g]	33.33 (5.81)[h]
S.Em ±	**0.09**	**0.09**	**0.06**	**0.06**	**0.09**	**0.06**
CD @ 5%	**0.26**	**0.28**	**0.19**	**0.17**	**0.27**	**0.16**
CV (%)	**9.38**	**9.52**	**8.69**	**8.55**	**9.61**	**11.55**

DBS – Day before spray **DAS – Days after spray**

Mean followed by the same letters in a column do not differ significantly, Figures in parentheses are $\sqrt{x + 0.5}$ transformed values.

T_2 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray of fipronil 5 SC @ 1 ml/l.) which recorded 13.07 and 13.33 thrips per plant respectively, T_5 (no seed treatment + one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l + one spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l) recorded a minimal population of 13.83 thrips per plant but it was on par with T_7 (no seed treatment + no spray in nursery and two sprays with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l) which recorded 15.00 thrips per plant. Treatment T_1 (seed treatment with imidacloprid 60 FS @ 9 ml/l/kg of seed) was found to be inferior to all other treatment by recording a highest thrips population of 16.90 thrips per plant followed by untreated control (19.33 thrips/ plant) (Plate 6 and plate 7).

One day after spray

A day after spraying, the number of thrips per plant ranged from 1.80 to 19.00. Significantly least number of thrips recorded in T_4 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two sprays with thiamethoxam 25 WG @ 0.2 g/l + fipronil 5 SC @ 1 ml/l and one spray of chlorantraniliprole 18.5 SC @ 0.15 ml/l) 1.80 per plant and T_6 (no seed treatment, followed by one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two sprays with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one sprays with chlorantraniliprole 18.5 SC @ 0.15 ml/l) 2.23 thrips per plant and both the treatments were on par with each other. These were followed by T_7 (no seed treatment + no spray in nursery and two sprays with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l) which recorded population of 6.00 thrips per plant and the treatments T_3 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray with fipronil 5 SC @ 1 ml/l + one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.), T_2 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray of fipronil 5 SC @ 1 ml/l.), T_5 (no seed treatment + one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l + one spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l) recorded increasing number of population ranging from 13.50 to 14.37 thrips per plant, but were on par with each other. Again T_1 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed) was found to be inferior by recording 17.00 thrips per plant followed by T_8 (19.00 thrips/plant).

Three days after spray

Three days after spray, the number of thrips per plant ranged between 1.07 and 21.80 in different treatments. Lowest number of thrips was recorded in T_4 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two sprays with thiamethoxam 25 WG @ 0.2 g/l + fipronil 5 SC @ 1 ml/l and one spray of chlorantraniliprole 18.5 SC @ 0.15 ml/l) 1.07 per plant which is superior over all other treatment. This was followed by T_6 (no seed treatment, followed by one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two sprays with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one sprays with chlorantraniliprole 18.5 SC @ 0.15 ml/l) and T_7 (no seed treatment + no spray in nursery and two sprays with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l) which recorded 1.52 and 3.93 thrips per plant respectively. Though treatments T_3 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray with fipronil 5 SC @ 1 ml/l + one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.) and T_2 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray of fipronil 5 SC @ 1 ml/l.) recorded a population of 14.67 and 15.53 thrips per plant and were on par T_5 (no seed treatment + one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l + one spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l) (16.03 thrips/plant). In T_1 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed) and T_8 (untreated control) the population increased to 19.10 and 21.80 thrips per plant which were inferior to all other treatments.

Five days after spray

Five days after spray, the number of thrips per plant ranged between 0.40 and 24.17 in sprayed and unsprayed treatment. Less number of 0.40 thrips per plant was recorded in T_4 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two sprays with thiamethoxam 25 WG @ 0.2 g/l + fipronil 5 SC @ 1 ml/l and one spray of chlorantraniliprole 18.5 SC @ 0.15 ml/l) followed by T_6 (no seed treatment, followed by one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two sprays with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one sprays with chlorantraniliprole 18.5 SC @ 0.15 ml/l) recorded 0.93 thrips per plant. Treatment T_3 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray with fipronil 5 SC @ 1 ml/l + one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.) and T_2 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray of fipronil 5 SC @ 1 ml/l.) registered thrips population of 16.33 and 18.13 per plant and were on par with each other but treatment T_5 (no seed treatment + one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l + one spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l) recorded 19.00 thrips per plant. Untreated control T_8 recorded highest population of 24.17 thrips per plant.

Ten days after spray

Ten days after spray, the number of thrips per plant ranged between 0.20 and 26.33 in sprayed and unsprayed treatment. Minimum number of 0.20 thrips per plant was observed in T_4 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two sprays with thiamethoxam 25 WG @ 0.2 g/l + fipronil 5 SC @ 1 ml/l and one spray of chlorantraniliprole 18.5 SC @ 0.15 ml/l) followed by T_6 (no seed treatment, followed by one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two sprays with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one sprays with chlorantraniliprole 18.5 SC @ 0.15 ml/l) 0.81 thrips per plant. And T_7 (no seed treatment + no spray in nursery and two sprays with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l) 2.10 thrips per plant. T_5 (no seed treatment + one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l + one spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l) recorded 21.33 thrips per plant. Other treatment like T_1 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed) and T_8 (untreated control) recorded highest population of 25.00 and 26.33 thrips per plant and were on par with each other.

Fifteen days after spray

Fifteen days after spray, the number of thrips per plant ranged between 0.35 and 28.67 in both sprayed and unsprayed treatment. Minimum number of 0.35 thrips per plant was observed in T_4 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two sprays with thiamethoxam 25 WG @ 0.2 g/l + fipronil 5 SC @ 1 ml/l and one spray of chlorantraniliprole 18.5 SC @ 0.15 ml/l) followed by T_6 (no seed treatment, followed by one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two sprays with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one sprays with chlorantraniliprole 18.5 SC @ 0.15 ml/l) 1.10 thrips per plant and T_7 (no seed treatment + no spray in nursery and two sprays with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l) 2.30 thrips per plant). Treatments T_1 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed) and T_8 (untreated control) were ineffective by recording highest thrips population of 27.17 and 28.67 per plant respectively.

4.3.2 Management of defoliators

One day before spray

The observations was recorded a day before spray in each treatment. The population of defoliators per plant a day before imposition of treatments in different treatments was

Table 12. Optimization of plant protection schedule for the management of *Thrips tabaci* on onion (second spray)

Treatment details	Number of thrips/plant						Yield (t/h)
	1 DBS	**1 DAS**	**3 DAS**	**5 DAS**	**10 DAS**	**15 DAS**	
T$_1$: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed.	16.90 (4.17)^{bcde}	17.00 (4.18)^{d}	19.10 (4.43)^{f}	23.33 (4.88)^{f}	25.00 (5.05)f	27.17 (5.25)f	18.20
T$_2$: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray of fipronil 5 SC @ 1 ml/l.	13.33 (3.72)^{b}	13.50 (3.74)c	15.53 (4.00)d	18.13 (4.32)d	20.13 (4.54)d	22.50 (4.79)e	21.94
T$_3$: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray with fipronil 5 SC @ 1 ml/l + one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.	13.07 (3.68)^{b}	13.71 (3.77)c	14.67 (3.89)d	16.33 (4.10)d	18.43 (4.35)d	20.10 (4.54)d	21.67
T$_4$: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two spray with fipronil 5 SC @ 1 ml/l + thiamethoxam 25 WG @ 0.2 g/l and one spray of chlorantraniliprole 18.5 SC @ 0.15 ml/l.	10.17 (3.27)^{a}	1.80 (1.52)a	1.07 (1.25)a	0.40 (0.95)a	0.20 (0.83)a	0.35 (0.92)a	24.44
T$_5$: No seed treatment + one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l + one spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l	13.83 (3.79)^{bc}	14.37 (3.86)c	16.03 (4.07)de	19.00 (4.41)de	21.33 (4.67)de	23.00 (4.85)e	22.78
T$_6$: No seed treatment, one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two spray with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.	11.33 (3.43)^{b}	2.23 (1.65)a	1.52 (1.42)b	0.93 (1.20)b	0.81 (1.14)b	1.10 (1.26)b	23.89
T$_7$: No seed treatment + no spray in nursery and two spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.	15.00 (3.94)^{bcd}	6.00 (2.54)b	3.93 (2.10)c	2.50 (1.73)c	2.10 (1.61)c	2.30 (1.67)c	20.27
T$_8$: Untreated control.	19.33 (4.45)^{bcde}	19.00 (4.41)^{e}	21.80 (4.72)g	24.17 (4.96)f	26.33 (5.17)f	28.67 (5.40)f	11.50
S.Em±	**0.10**	**0.07**	**0.08**	**0.07**	**0.08**	**0.07**	**0.72**
CD @ 5%	**0.29**	**0.22**	**0.11**	**0.22**	**0.24**	**0.23**	**2.20**

DBS – Day before spray **DAS – Days after spray**

Mean followed by the same letters in a column do not differ significantly, Figures in parentheses are $\sqrt{x + 0.5}$ transformed values.

uniform as indicated by statistical analysis which ranged from 1.10 to 1.18 defoliators per plant (Table 13) (Plate 6 and plate 7).

One day after spray

One day after spray, the number of defoliators per plant ranged between 0.30 and 1.17. Significantly least population of larvae per plant was recorded in T_4 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two sprays with thiamethoxam 25 WG @ 0.2 g/l and fipronil 5 SC @ 1 ml/l and one spray of chlorantraniliprole 18.5 SC @ 0.15 ml/l) which was 0.30 larvae per plant and in T_6 (no seed treatment, followed by one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two sprays with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one sprays with chlorantraniliprole 18.5 SC @ 0.15 ml/l) which recorded 0.32 larvae per plant and they were on par with each other. Followed by the treatment T_3 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray with fipronil 5 SC @ 1 ml/l + one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.), T_7 (no seed treatment + no spray in nursery and two sprays with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l) and T_5 (no seed treatment + one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l + one spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l) which recorded the defoliators population of 0.40, 0.40 and 0.42 larvae per plant respectively and these were found to be on par with one another. Treatment T_2 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray of fipronil 5 SC @ 1 ml/l.), T_8 (untreated control) and T_1 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed) recorded higher defoliators population of 1.10, 1.14 and 1.17 larvae per plant respectively.

Three day after spray

Three days after spray, the number of defoliators larvae per plant ranged between zero to 1.21. T_4 (Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two sprays with thiamethoxam 25 WG @ 0.2 g/l + fipronil 5 SC @ 1 ml/l and one spray of chlorantraniliprole 18.5 SC @ 0.15 ml/l) and T_6 (no seed treatment, followed by one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two sprays with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one sprays with chlorantraniliprole 18.5 SC @ 0.15 ml/l) excelled to all other treatment where in there was no incidence of defoliators. These treatments were followed by T_3 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray with fipronil 5 SC @ 1 ml/l + one spray with chlorantraniliprole 18.5 SC @ 0.15

ml/l.) and T_5 (no seed treatment + one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l + one spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l) which recorded the defoliators population of 0.22 and 0.23 larvae per plan respectively, and these were on par with each other. Significantly higher population of defoliators was seen in T_8 (untreated control) T_2 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray of fipronil 5 SC @ 1 ml/l.) and T_1 (seed treatment with imidacloprid 60 FS @ 9 ml/k of seed) 1.13, 1.16 and 1.21 larvae per plant respectively and these were on par with one another.

Five day after spray

Five days after spray, the number of defoliators per plant ranged between zero to 1.24. Five day after spray T_4 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two sprays with thiamethoxam 25 WG @ 0.2 g/l + fipronil 5 SC @ 1 ml/l and one spray of chlorantraniliprole 18.5 SC @ 0.15 ml/l) and T_6 (no seed treatment, followed by one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two sprays with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one sprays with chlorantraniliprole 18.5 SC @ 0.15 ml/l) were free from defoliators and were on par with each other. These treatments were followed by T_3 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray with fipronil 5 SC @ 1 ml/l + one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.) and T_5 (no seed treatment + one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l + one spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l) which recorded the defoliators population of 0.10 and 0.12 larvae per plant and these were on par with each other. Incidence of defoliators was higher in T_2 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray of fipronil 5 SC @ 1 ml/l.), T_8 (untreated control) and T_1 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed) which recorded defoliators population of 1.20, 1.23 and 1.24 larvae per plant respectively. These were on par with each other.

Ten day after spray

Ten days after spray, the number of defoliators per plant ranged between 0.10 to 1.26. Significantly lowest population (0.10 larvae/plant) was recorded in T_4 (Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two sprays with thiamethoxam 25 WG @ 0.2 g/l + fipronil 5 SC @ 1 ml/l and one spray of chlorantraniliprole 18.5 SC @ 0.15 ml/l) which was on par with all other treatment except T_1 which noticed highest population of defoliators 1.26 larva per plant which was on par with T_8 (untreated control) and T_2 (seed treatment with

Plate 6. Field view of seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed followed by two spray with thiamethoxam 25 WG @ 0.2 g/l + fipronil 5 SC @ 1 ml/l and one spray of chlorantraniliprole 18.5 SC @ 0.15 ml/l

Plate 7. Field view of untreated control plot

imidacloprid 60 FS @ 9 ml/kg of seed + one spray of fipronil 5 SC @ 1 ml/l.) (1.25 and 1.24 larva/plant respectively).

Fifteen day after spray

Fifteen days after spray, the number of larvae per plant ranged between 0.12 to 1.31. There was an overall increase in defoliators population from 0.12 to 0.18 larvae per plant in all treatments except T_2 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray of fipronil 5 SC @ 1 ml/l.), T_1 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed) and T_8 (untreated control) were recorded the defoliators population of 1.27, 1.30 and 1.31 larvae per plant respectively and these three treatment were on par with each other.

4.3.3 Influence of insecticides on spiders

First spray

The day before spraying there were no significant different between the treatments (Table 14). After 5 DAS, T_8 (untreated control) and T_1 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed) recorded higher population of 1.23 and 1.00 spiders per plant. there was no significant difference found among the all other treatments and all were on par with each.

After 10 DAS only T_8 (untreated control) and T_1 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed) recorded 1.43 and 1.36 spiders per plant which were on par and were superior to all other treatments. This was followed by T_2 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray of fipronil 5 SC @ 1 ml/l.) and T_7 (no seed treatment + no spray in nursery and two sprays with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l) which recorded population from 0.50 and 0.60 spiders per plant respectively. After 15 DAS similar trend was noticed with increase in spiders population where in T_8 (untreated control) and T_1 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed) recorded 1.73 and 1.70 spiders per plant respectively, T_2 to T_7 which recorded minimum population raising from 0.65 to 0.81 spiders per plant and were on par with each other.

Second spray

The day before spraying there were no significant different between the treatments and all were on par with each other (Table 14). After 5 days of second spraying except T_6 and $T_{4,}$ all the treatments recorded highest population raising from 1.81 to 1.70 spiders per

Table 13. Optimization of plant protection schedule for the management of defoliators on onion

Treatment details	Number of defoliators/plant					
	1 DBS	**1 DAS**	**3 DAS**	**5 DAS**	**10 DAS**	**15 DAS**
T_1: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed.	1.13 (1.28)a	1.17 (1.29)[c]	1.21 (1.31)c	1.24 (1.32)[d]	1.26 (1.33)[c]	1.30 (1.34)[b]
T_2: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray of fipronil 5 SC @ 1 ml/l.	1.10 (1.26)a	1.10 (1.27)c	1.16 (1.29)c	1.20 (1.30)[d]	1.24 (1.32)c	1.27 (1.33)[b]
T_3: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray with fipronil 5 SC @ 1 ml/l + one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.	1.14 (1.28)a	0.40 (0.95)[ab]	0.22 (0.85)b	0.10 (0.77)b	0.12 (0.79)a	0.13 (0.80)[a]
T_4: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two spray with fipronil 5 SC @ 1 ml/l + thiamethoxam 25 WG @ 0.2 g/l and one spray of chlorantraniliprole 18.5 SC @ 0.15 ml/l.	1.17 (1.29)a	0.30 (0.89)a	0.00 (0.71)a	0.00 (0.71)a	0.10 (0.77)[a]	0.12 (0.79)[a]
T_5: No seed treatment + one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l + one spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l	1.10 (1.26)a	0.42 (0.96)[ab]	0.23 (0.85)b	0.12 (0.79)[b]	0.14 (0.80)[a]	0.17 (0.82)[a]
T_6: No seed treatment, one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two spray with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.	1.18 (1.29)a	0.32 (0.91)[a]	0.00 (0.71)a	0.00 (0.71)[a]	0.12 (0.79)[a]	0.14 (0.80)[a]
T_7: No seed treatment + no spray in nursery and two spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.	1.13 (1.28)a	0.40 (0.95)[ab]	0.25 (0.87)[b]	0.15 (0.81)bc	0.16 (0.81)[ab]	0.18 (0.82)[a]
T_8: Untreated control.	1.10 (1.26)a	1.14 (1.28)[c]	1.13 (1.28)c	1.23 (1.31)d	1.25 (1.32)c	1.31 (1.35)[b]
S.Em ±	**0.02**	**0.02**	**0.01**	**0.01**	**0.01**	**0.01**
CD @ 5%	**NS**	**0.05**	**0.03**	**0.03**	**0.03**	**0.03**
CV (%)	**9.35**	**10.76**	**8.18**	**9.50**	**8.74**	**8.90**

DBS – Day before spray **DAS – Days after spray**

Mean followed by the same letters in a column do not differ significantly, Figures in parentheses are $\sqrt{x + 0.5}$ transformed values.

Table 14. Effect of plant protection schedule on the population of spiders on onion (first and second spray)

Treatment details	Number of spiders/plant							
	First spray				Second spray			
	1 DBS	5 DAS	10 DAS	15 DAS	1 DBS	5 DAS	10 DAS	15 DAS
T_1: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed.	0.36 (0.93)a	1.00 (1.22)b	1.36 (1.37)a	1.70 (1.48)a	1.66 (1.46)a	1.81 (1.52)a	2.10 (1.61)a	2.46 (1.72)a
T_2: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray of fipronil 5 SC @ 1 ml/l.	0.34 (0.92)a	0.42 (0.96)c	0.50 (1.00)b	0.74 (1.11)b	1.60 (1.45)a	1.70 (1.48)a	1.85 (1.53)ab	2.13 (1.62)ab
T_3: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray with fipronil 5 SC @ 1 ml/l + one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.	0.35 (0.92)a	0.44 (0.97)c	0.52 (1.01)[b]	0.67 (1.08)b	01.65 (1.47)a	1.71 (1.49)a	1.83 (1.53)ab	2.00 (1.58)[abc]
T_4: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two spray with fipronil 5 SC @ 1 ml/l + thiamethoxam 25 WG @ 0.2 g/land one spray of chlorantraniliprole 18.5 SC @ 0.15 ml/l.	0.37 (0.93)a	0.43 (0.96)c	0.50 (1.00)b	0.70 (1.10)b	1.62 (1.45)a	0.52 (1.01)c	0.67 (1.08)d	0.81 (1.14)e
T_5: No seed treatment + one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l + one spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l	0.30 (0.89)b	0.36 (0.93)cde	0.48 (0.99)[bc]	0.65 (1.07)b	1.66 (1.47)a	1.78 (1.51)a	1.90 (1.55)ab	2.15 (1.63)[ab]
T_6: No seed treatment, one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two spray with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.	0.32 (0.91)a	0.38 (0.94)cd	0.51 (1.01)b	0.75 (1.12)b	1.60 (1.45)a	0.60 (1.05)c	0.73 (1.11)d	0.73 (1.11)e
T_7: No seed treatment + no spray in nursery and two spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.	0.32 (0.91)a	0.47 (0.98)c	0.60 (1.05)b	0.81 (1.14)[b]	1.66 (1.47)a	0.80 (1.14)b	0.94 (1.20)c	1.20 (1.31)d
T_8: Untreated control.	0.40 (0.95)a	1.23 (1.32)a	1.43 (1.39)a	1.73 (1.49)a	1.70 (1.48)[a]	1.83 (1.52)a	2.23 (1.65)[a]	2.52 (1.73)[a]
S.Em ±	**0.01**	**0.01**	**0.02**	**0.02**	**0.03**	**0.02**	**0.03**	**0.03**
CD @ 5%	**0.04**	**0.04**	**0.05**	**0.07**	**NS**	**0.06**	**0.08**	**0.09**
CV (%)	**11.15**	**8.98**	**10.68**	**10.86**	**9.70**	**8.05**	**9.55**	**10.16**

DBS – Day before spray **DAS – Days after spray**

Mean followed by the same letters in a column do not differ significantly, Figures in parentheses are $\sqrt{x + 0.5}$ transformed values.

plant these treatment were on par with each other. After 10 DAS excepts $T_{7,}$ T_6 and T_4 all registered maximum population raising from 2.23 to 1.83 spiders per plant.

After 15 DAS except $T_{7,}$ T_6 and $T_{4,}$ all were found to be superior by recording higher population raising from 2.52 to 2.00 spiders per plant which were on par with each other.

4.3.4 Influence of insecticides on coccinellids

First spray

The day before spraying there were no significant different between the treatments and all were on par with each other (Table 15). After 5 DAS only T_8 (untreated control) and T_1 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed) noticed 0.20 and 0.18 coccinellids per plant and these were superior to all other treatments. But there were no significant difference found among the treatments from T_2 to T_7 which recorded zero population.

After 10 DAS T_8 (untreated control) and T_1 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed) registered 0.26 and 0.24 coccinellids per plant where T_8 and were superior to all other treatments, the next best treatment were T_2 and T_7 which recorded minimum population of 0.07 cocinellids per plant. There were no significant difference found among the treatments T_3 to T_6 which recorded zero population. After 15 DAS similar trend was noticed with an increase in coccinellids population where T_8 and T_1 recorded 0.30 and 0.25 coccinellids per plant respectively. Population from T_2 to T_7 which recorded 0.10 to 0.09 coccinellids per plant

Second spray

The day before second spraying the population ranged from 0.10 to 0.40 coccinellids per plant (Table 15) but there was no significant difference among the treatments. After five days of second spraying T_8 (untreated control) recorded significantly higher population of 0.44 coccinellids per plant followed by T_1 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed) 0.40 coccinellids per plant and were on par with each other. No significant difference was found among the treatments T_2 and T_5 (no seed treatment + one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l + one spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l) which recorded 0.15 coccinellids per plant and next best treatments were T_3 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray with fipronil 5 SC @ 1 ml/l + one spray with chlorantraniliprole 18.5 SC

Table 15. Effect of plant protection schedule on population of coccinellids on onion (first and second spray

Treatment details	Number of coccinellids/plant							
	First spray				Second spray			
	1 DBS	**5 DAS**	**10 DAS**	**15 DAS**	**1 DBS**	**5 DAS**	**10 DAS**	**15 DAS**
T_1: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed.	0.13 (0.79)^{a}	0.18 (0.82)a	0.24 (0.86)a	0.25 (0.87)^{a}	0.30 (0.89)^{a}	0.40 (0.95)a	0.44 (0.97)b	0.48 (0.99)a
T_2: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray of fipronil 5 SC @ 1 ml/l.	0.10 (0.77)^{b}	0.00 (0.71)^{c}	0.07 (0.75)^{c}	0.10 (0.77)^{b}	0.15 (0.81)^{ab}	0.15 (0.81)c	0.17 (0.82)^{c}	0.20 (0.84)^{b}
T_3: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray with fipronil 5 SC @ 1 ml/l + one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.	0.13 (0.79)^{a}	0.01 (0.71)^{c}	0.00 (0.71)^{d}	0.07 (0.75)^{bc}	0.12 (0.79)^{ab}	0.14 (0.80)^{d}	0.18 (0.82)^{c}	0.22 (0.85)^{b}
T_4: Seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two spray with fipronil 5 SC @ 1 ml/l + thiamethoxam 25 WG @ 0.2 g/l and one spray of chlorantraniliprole 18.5 SC @ 0.15 ml/l.	0.13 (0.79)^{a}	0.00 (0.71)^{c}	0.00 (0.71)^{d}	0.07 (0.75)^{bc}	0.10 (0.77)^{ab}	0.00 (0.71)^{e}	0.00 (0.71)^{e}	0.10 (0.77)^{b}
T_5: No seed treatment + one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l + one spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l	0.14 0.80)^{a}	0.00 (0.71)^{c}	0.00 (0.71)^{d}	0.07 (0.75)^{bc}	0.12 (0.79)^{ab}	0.15 (0.80)^{c}	0.17 (0.82)^{d}	0.19 (0.83)^{b}
T_6: No seed treatment, one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two spray with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.	0.12 (0.79)^{a}	0.00 (0.71)^{c}	0.00 (0.71)^{d}	0.07 (0.75)^{bc}	0.14 (0.80)^{ab}	0.00 (0.71)^{e}	0.00 (0.77)^{e}	0.12 (0.79$^{)b}$
T_7: No seed treatment + no spray in nursery and two spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.	0.12 (0.79)^{a}	0.01 (0.71)^{c}	0.07 (0.75)^{c}	0.09 (0.77)^{b}	0.15 (0.81)^{ab}	0.00 (0.71)^{e}	0.00 (0.71)^{e}	0.08 (0.76)^{bc}
T_8: Untreated control.	0.13 (0.79)^{a}	0.20 (0.84)^{a}	0.26 (0.87)^{a}	0.30 (0.89)^{a}	0.40 (0.94)^{a}	0.44 (0.97)^{a}	0.48 (0.99)^{a}	0.51 (1.00)^{a}
S.Em ±	**0.01**	**0.00**	**0.00**	**0.02**	**0.03**	**0.01**	**0.00**	**0 .01**
CD @ 5%	**0.02**	**0.01**	**0.01**	**0.06**	**0.08**	**0.02**	**0.01**	**0.02**

DBS – Day before spray **DAS – Days after spray**

Mean followed by the same letters in a column do not differ significantly, Figures in parentheses are $\sqrt{x+0.5}$ transformed values.

@ 0.15 ml/l.) which recorded 0.14 coccinellids per plant, whereas other treatments recorded zero population.

After 10 DAS again T_8 (untreated control) and T_1 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed) were found to be superior by recording 0.48 and 0.44 coccinellids per plant respectively, remaining treatments were on par with each other. After 15 DAS similar trend continued in T_8 and T_1 (0.51 and 0.48 coccinellids/ plant respectively) and there were no significant difference in the population of coccinellids in all other treatments.

4.3.4.1 Yield

Maximum bulb yield of onion 24.44 t/ha was recorded in T_4 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two sprays with thiamethoxam 25 WG @ 0.2 g/l + fipronil 5 SC @ 1 ml/l and one spray of chlorantraniliprole 18.5 SC @ 0.15 ml/l) followed by T_6 (no seed treatment, followed by one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two spray with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one sprays with chlorantraniliprole 18.5 SC @ 0.15 ml/l) which recoded (23.89 t/ ha) (Table 12). Significantly lowest yield was obtained in T_8 (untreated control) (11.50 t/ ha).

4.3.4.2 Economics of management of pests of onion

Calculation of economics of treatment costs in various treatments used for the management of insects pests of onion revealed that highest benefits costs ratio of 1:13 was obtained in the T_4 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two spray with thiamethoxam 25 WG @ 0.2 g/l + fipronil 5 SC @ 1 ml/l and one spray of chlorantraniliprole 18.5 SC @ 0.15 ml/l) this was followed T_6 (no seed treatment, one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two spray with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l) which was recorded 1:12. Thus proving their superiority compared to other treatments. Lowest benefit cost ratio of 1:6.5 was obtained in T_8 (untreated control) (Table 16).

Table 16. Economics of management of pests of onion

Treatment details	Yield (t/ha)	Common cost of cultivation/ha	Cost of treatments/ha	Total cost/ha	Gross returns/ha	Net returns/ha	B:C Ratio
T_1: Seed treatment with imidacloprid 60 FS @ 9ml/kg of seed.	18.20	35000	458	35458	364000	328542	10.27
T_2: Seed treatment with imidacloprid 60 FS @ 9ml/kg of seed + one spray of fipronil 5 SC @ 1ml/l.	21.94	35000	1112	36112	438800	402688	12.15
T_3: Seed treatment with imidacloprid 60 FS @ 9ml/kg of seed + one sprays with fipronil 5 SC @ 1ml/l + one spray with chlorantraniliprole 18.5 SC @ 0.15ml/l.	21.67	35000	1862	36862	433400	396538	11.76
T_4: Seed treatment with imidacloprid 60 FS @ 9ml/kg of seed + two spray with fipronil 5 SC @ 1ml/l + thiamethoxam 25 WG @ 0.2 g/l and one sprays of chlorantraniliprole 18.5 SC @ 0.15 ml/l.	24.44	35000	2147	37147	488800	451653	13.16
T_5: No seed treatment + one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l + one spray with fipronil 5 SC @ 1ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15ml/l	22.78	35000	1652	36652	455600	418948	12.43
T_6: No seed treatment, one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two sprays with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.	23.89	35000	1937	36937	477800	440863	12.94
T_7: No seed treatment + No spray in nursery and two spray with fipronil 5 SC @ 1 ml/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.	20.27	35000	1742	36742	405400	368658	11.03
T_8: Untreated control.	11.50	35000	-	35000	230000	195000	6.57

DISCUSSION

V. DISCUSSION

Thrips infestations on many crops have become more important over the past few decades. Often considered only as incidental or secondary pests, today they are responsible for causing considerable damage especially in onion, garlic and other allied crops. Considering on a worldwide basis, the onion thrips probably does more damage to onions than do all other pests combined. In India 50 per cent of onion crop may be lost as a result of attack by thrips. It becomes imperative to have detailed understanding about its distribution in different areas through survey, seasonal incidence and devising economically and environmentally sound management practices by generating research data on the above aspects of the pest. Hence, the present study was undertaken and salient findings of the various aspects of investigations are discussed in the light of earlier work done in the present chapter.

5.1 Survey for incidence of insect pests and their natural enemies on onion in Hyderabad-Karnataka region

5.1.1 Survey for insect pests of onion

Thrips tabaci

The incidence of thrips was noticed through the year in all the locations with variations in activity during different months (Fig. 1). The population of thrips in Raichur district varied from 10.81 to 18.38 thrips per plant where in, lowest incidence was recorded in the month of August and highest incidence during February. In Gulbarga district the populations of thrips were comparatively higher and it ranged from 15.10 to 25.77 thrips per plant. The highest population was recorded in the month of February and lowest population in the month of August.

In Yadgir district the population of thrips varied from 11.76 to 17.10 thrips per plant, the lowest incidence was registered in the month of November and highest incidence was recorded in the month of February. Whereas, in Bellary district the population of thrips varied from 15.88 to 26.10 thrips per plant and the incidence was lowest in the month of August and highest during February. In all the four districts the infestation of thrips was more during the February and less during August. In the present study the low population in the month of August may be attributed to heavy rains which might has reduced the thrips population in July and September months and the high population in February was because of dry weather.

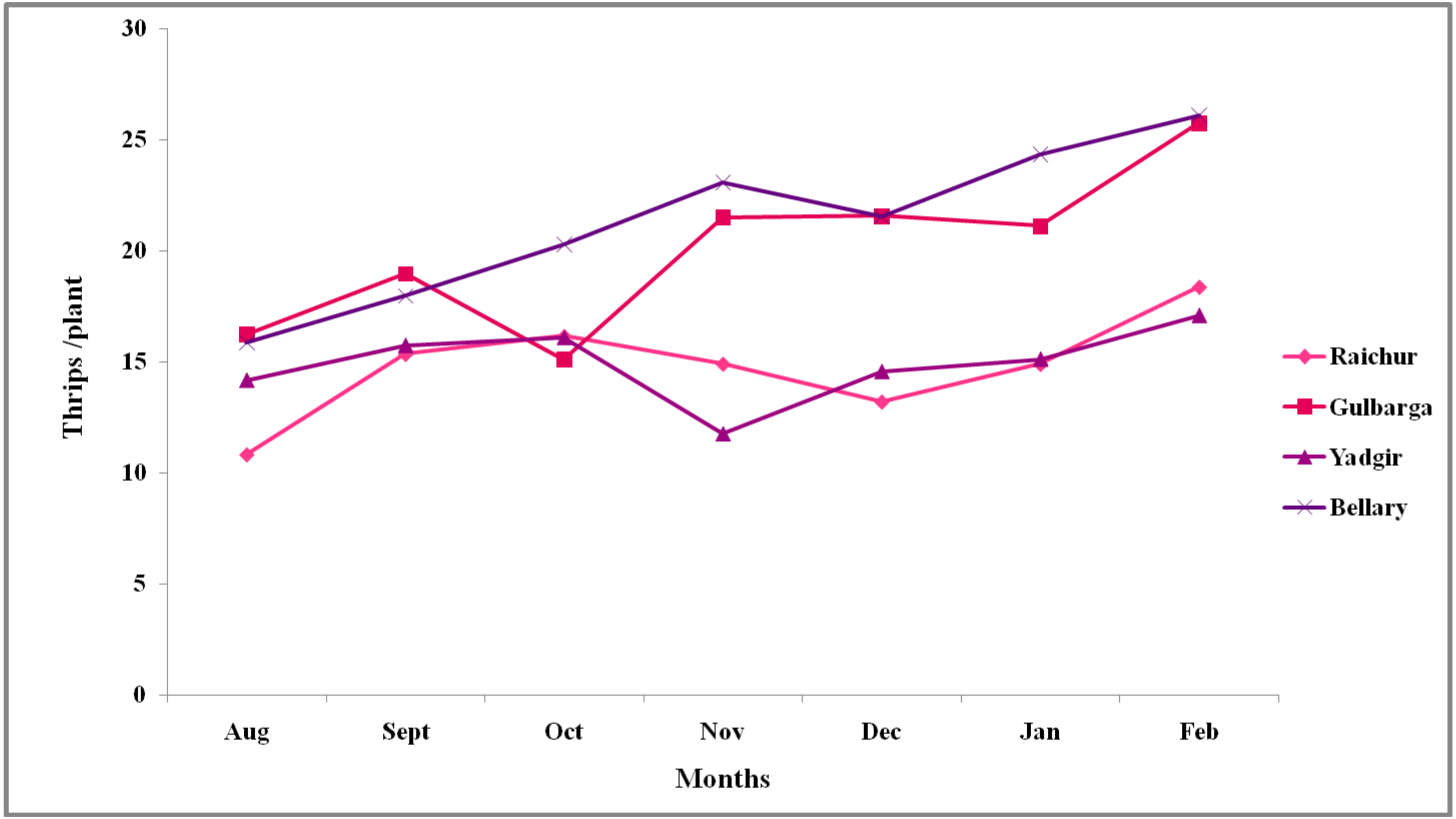


Fig. 1. Incidence of *Thrips tabaci* on onion in different districts of Hyderabad-Karnataka region

The present findings are in line with the findings of Ibrahim and Adesiyun (2010a) reported that population of thrips reached peak in late February (176 thrips/ plant). Similarly, Kranz *et al.* (1977) reported that the thrips population increase due to dry weather and decreases rapidly after rain. *Thrips tabaci* population thrive in warm and fairly in dry conditions, which not only promote fast larval development but are ideal for flight, the primary means by which the thrips migrate between hosts (Lewis, 1977c; Harding, 1996 and Kirk, 1997). However the results are in contradict with Macintyre *et al.* (2005) who reported peak population during August.

Defoliators

In Raichur district the population of defoliators varied from 0.45 to 2.35 larvae per plant (Fig. 2), lowest incidence was registered in the month of November and highest incidence during August. In Gulbarga district the population ranged from 0.40 to 2.25 larvae per plant and lowest incidence was recorded in the month of November and highest incidence was noticed during August.

In Yadgir district the population of defoliators varied from 0.70 to 2.75 larvae per plant, the lowest incidence was registered in the month of Febraury and highest during August. In Bellary district the defoliators varied from 0.20 to 1.10 larvae per plant, the lowest population was registered in the month February and highest during August.

Incidence of defoliators noticed on onion across different districts was non significant. This mainly due to lesser infestation of the defoliators as seen in all the location. The present findings are comparable with the findings of Adamcyzyk *et al.* (2002) who reported that moths of *Spodoptera exigua* were found in all the months but greatest numbers were found during September and October. Shailaja *et al*. (2006) studied population dynamics of *Spodoptera exigua* on onion during *rabi* season and found that pest activity was observed for ten weeks commencing from 46th to 3rd standard week with a peak larval density of 21.03 per ten plants during 1st standard week.

Ulrich and Mewis (2004) also reported the presence of armyworm *S. exigua* year round based on pheromone trap data.

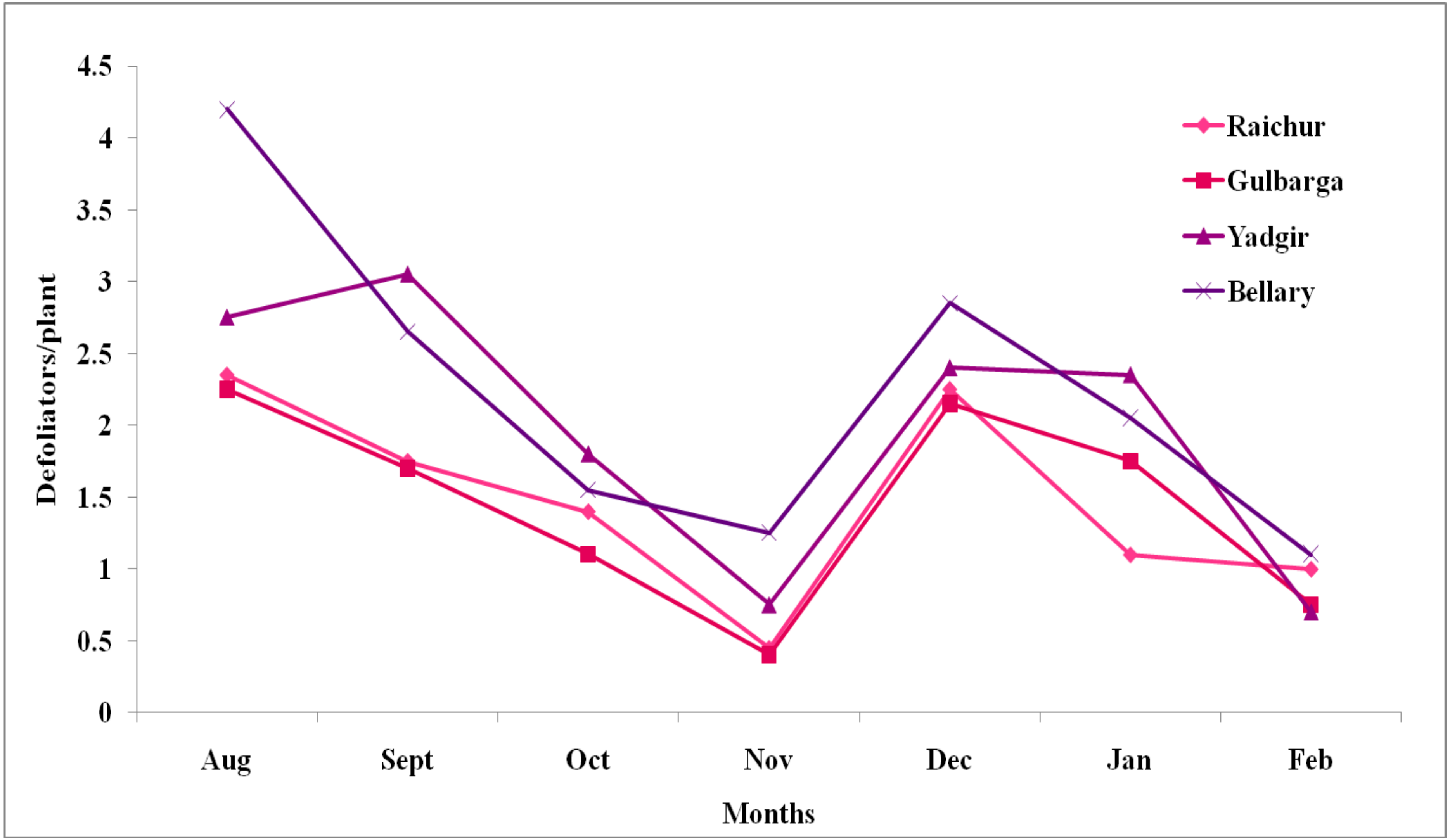


Fig. 2. Incidence of defoliators on onion in different districts of Hyderabad-Karnataka region.

5.1.2 Survey for natural enemies

Different natural enemies which were recorded during the survey in farmers fields of important onion growing district of Hyderabad Karnataka region were predators *viz*., spiders coccinellids.

Spiders

Spider population was found through the cropping season in Raichur district where in, the population ranged from 0.30 to 0.68 per plant (Fig. 3), lowest number was registered in the month of January and highest incidence was recorded during August. In Gulbarga district the population was highest in the month of November and lowest during October where as in Yadgir district the spider population was higher during August and lowest during the month of February. In Bellary district the population was lower during September and February months and highest during November.

Coccinellids

The population of coccinellids, *Coccinella transversalis* did not vary between the location and also during the different months. The population of coccinellids ranged from 0.18 to 0.27 in all the locations. (Fig. 4). However in Raichur the population was slightly higher during October month. Where in, Yadgir, Gulbarga and Bellary district higher population of coccinellids was recorded during the month of October and November months.

The present findings are comparable with the findings of Elaine and Brian (2012) reported that predators *viz.*, predatory thrips (aeolothripidae), hover fly larvae (syrphidae), ladybird beetles (coccinellidae), lace wing larvae (chrysopidae) and minute pirate bugs (anthocorid) on onion found to be more during mid July. Similarly, Joe (2012) reported eight beneficial predator and parasite families from the three fields sampled. The average of all populations of insects and arachnids at all locations revealed that ladybird beetle larva were the numerous followed by spiders, braconid wasps, syrphid flies, big eyed bugs, ladybird beetles, nabids and lace wings.

5.2 Influence of different dates of transplanting on the incidence of insect pests on onion

5.2.1 Incidence of *Thrips tabaci*

The infestation of thrips varied significantly across different dates of transplanting (Fig. 5). October 15th transplanted onion registered significantly lowest thrips population of

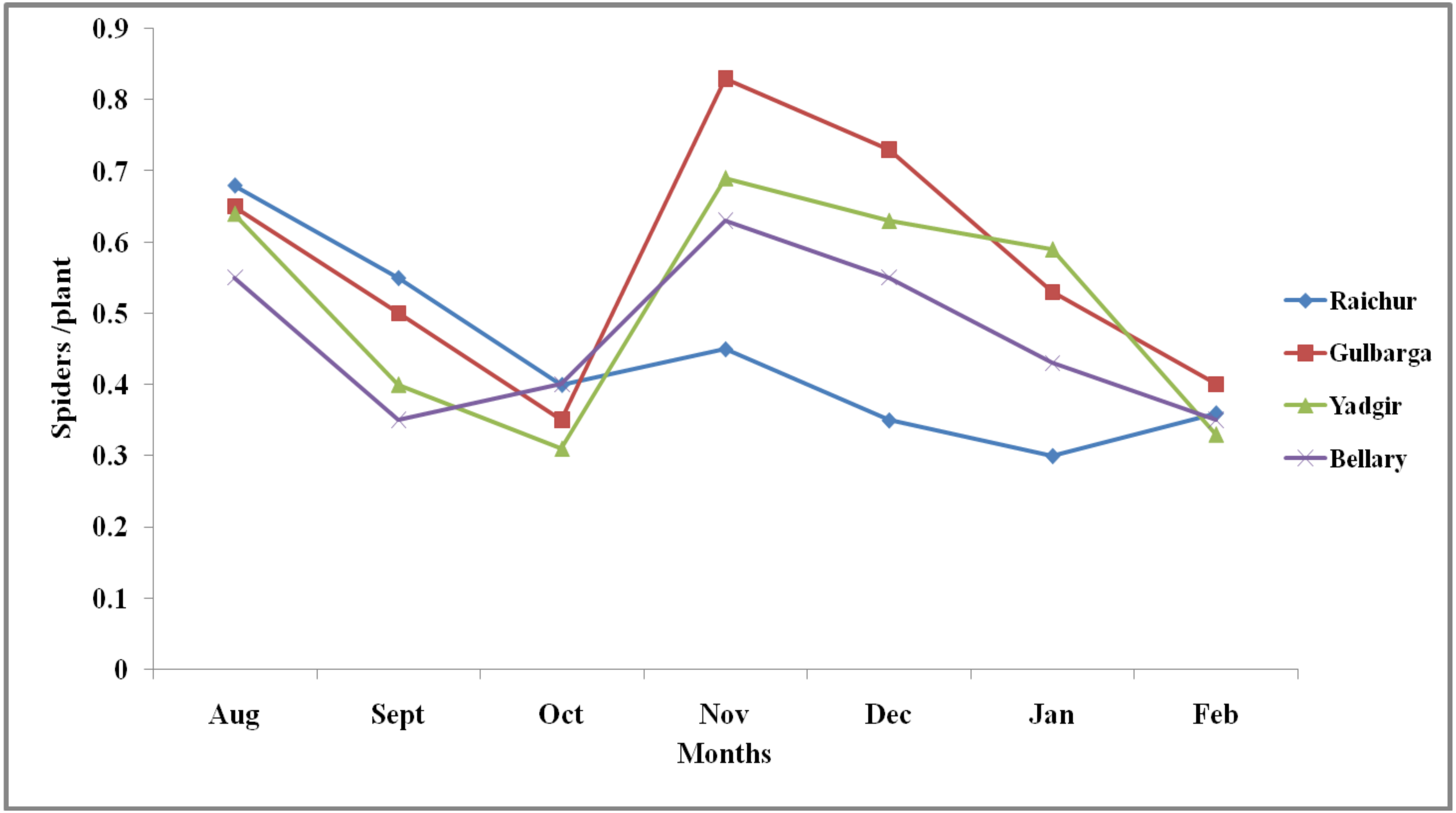


Fig. 3 Occurence of spiders on onion in different districts of Hyderabad-Karnataka region

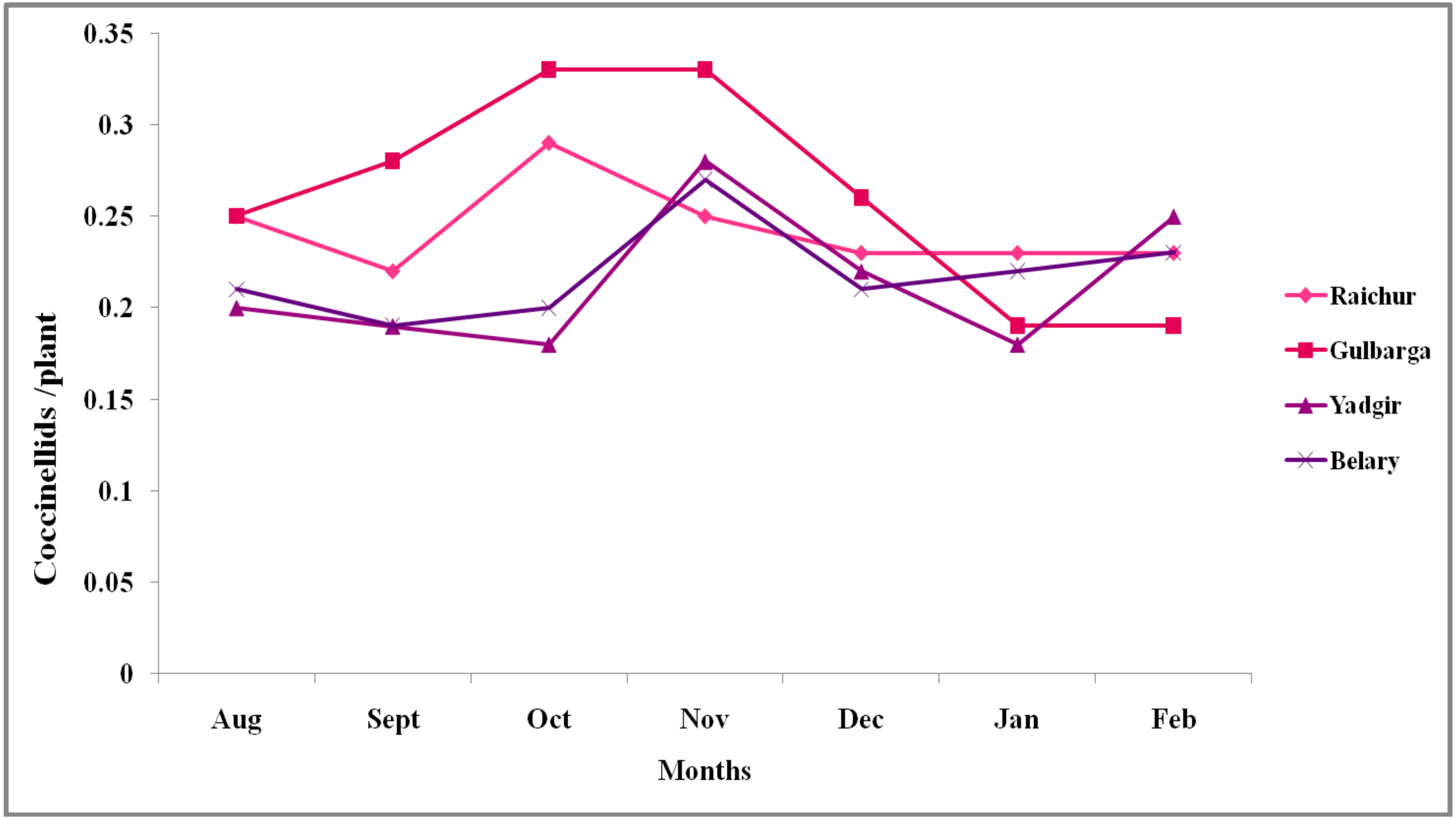


Fig. 4. Occurrence of coccinellids on onion in different districts of Hyderabad-Karnataka region

3.00 per plant followed by August 30th transplanted treatments. Thrips population was significantly higher in July 30th transplanted onion.

After 30 days after transplanting September 30th transplanted onion proved to be superior followed by October 15th. Transplanting early in *kharif* season *i.e.,* July 15th was found to be inferior which recorded higher population of thrips (16.67 thrips/plant).

The same trend was noticed when observation was registered at 45, 60, 75 and 90 days after transplanting. Transplanting of onion during September 30th and October 15th were found to be the optimum transplanting periods as they harboured less thrips.

Lower incidence of thrips in September and October transplanted situation might be attributed to high relative humidity prevailed during October and November months. Similarly, Franssen and Huisman (1958) reported that infestation of *Thrips angusticeps* uzel during rainy and cool season were significantly lower than those during dry and hot season, because of high larval mortality and slower population growth rate (Kirk, 1997). In support of present work Burgstaller and Hassan (1984) reported onion transplanting in October are well established before thrips infestations occurs (January and February) and produce high yield without applying insecticides.

Aswathanarayana and Gowdar (2005) reported the minimum thrips incidence in 5th August sowing (7.41 thrips/plant) and in 15th August sowing (5.36 thrips/plant) compared to 5th July sowing (20.7 and 11.4 thrips/plant). The highest disease intensity was recorded in early sown crop (June and July), followed by gradually declining disease intensity in later sown crop (August and September) in both the years. Highest bulb yield was obtained in 5th August (17.90 t/ha) and 15th August (19.80 t/ha respectively). Hence, sowing during 5th to 25th August is advantageous for thrips and disease control with higher bulb yields.

5.2.1.1 Correlation of incidence of thrips with weather parameters

Thrips population was correlated positively with maximum temperature and negatively with minimum temperature and rainfall which depicted that higher temperature favours the development of thrips whereas high rainfall found to be detrimental to thrips population. The results obtained from the present study are in line with the findings of Farman *et al.* (2010) who reported that thrips infestation showed a positive correlation with temperature (r=0.48) while relative humidity and rain showed negative correlation. Similarly, Domiciano *et al.* (1993) evaluated the population fluctuation of *T. tabaci* on onion at three

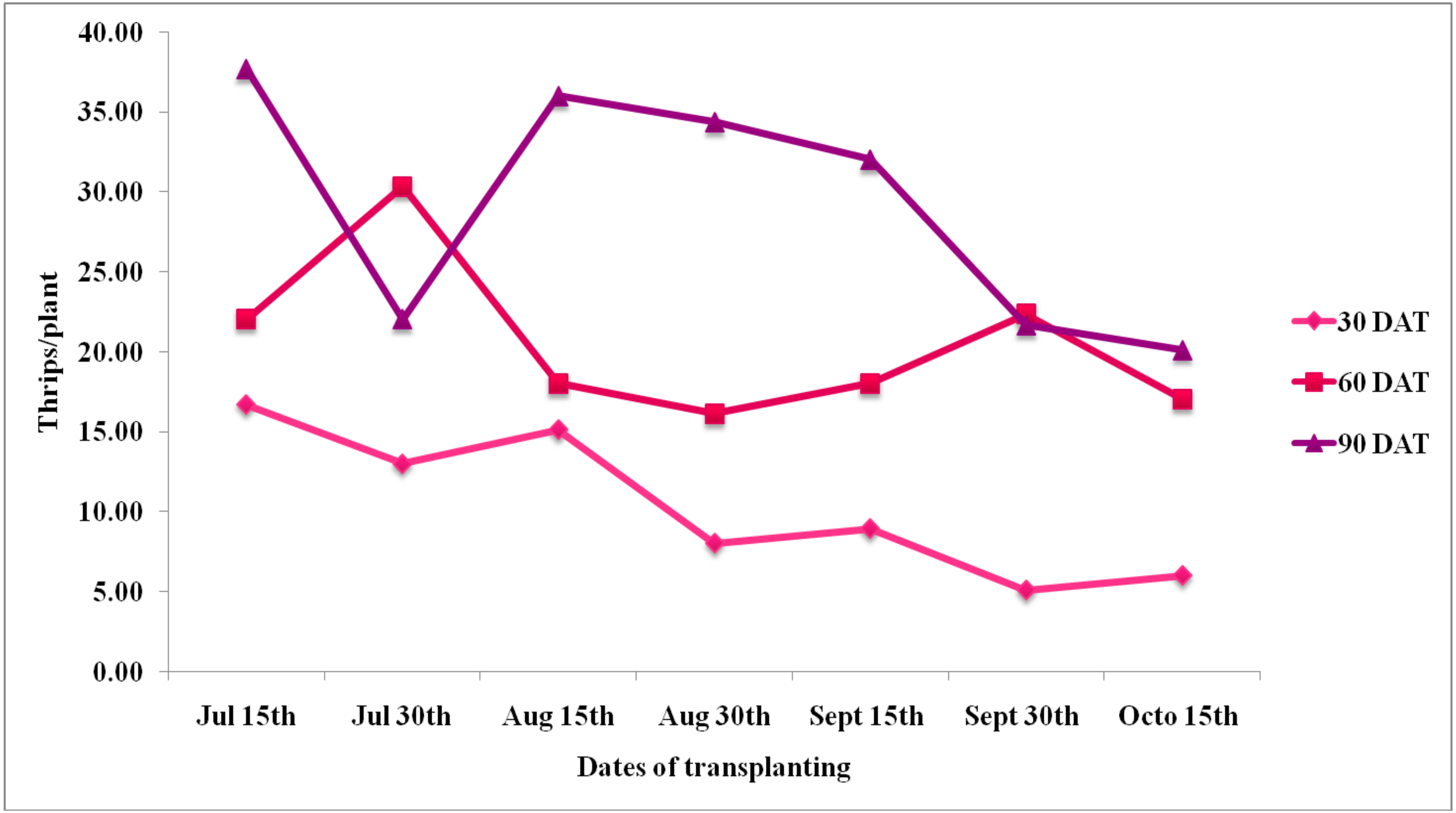


Fig. 5. Influence of different dates of transplanting of onion on the incidence of thrips

sowing dates with climatic elements and found that thrips population was negatively correlated with relative humidity and positively with temperature.

5.2.2 Incidence of defoliators

Population of defoliators varied greatly among different transplanting (Fig. 6). Observation registered at 15 days in July 15th transplanted onion was free from defoliators where as August 30th transplanted onion recorded highest population (0.53 larva/plant) which was on par with August 15th and September 15th transplantation dates.

After 30 days of transplanting September 30th and October 15th proved to be superior by recording lower population of defoliators whereas onion transplanted in the month of August recorded higher population. The same trend of observation were noticed at 45 and 60 days after transplanting whereas, at 90 days after transplanting there was no significant variation in population of defoliators between the different transplanting. Hence, onion transplanted on September 30th and October 15th recorded lowest incidence of defoliators and these dates were found to be optimum for reducing the incidence of defoliators.

5.2.3 Incidence of natural enemies in different dates of transplanting

5.2.3.1 Incidence of spiders

After 15 days after transplanting there was no significant fluctuation variation in the population of spiders in onion transplanted at different dates (Fig. 7). The same trend was noticed at 30 and 45 days after transplanting. After 60 days after transplanting October 15th and September 30th transplanted onion recorded highest number of spiders and it was low in July transplanted onion. Same trend continued at 75 DAT depicting that transplanting onion in September and October month supported higher population of natural enemies (spiders) whereas after 90 DAT there was no significant difference between the spider populations.

5.2.3.2 Incidence of coccinellids

Population of coccinellids varied significantly between the treatments. Observation recorded at 30, 45, 60, 75 and 90 days after transplanting revealed that September 30th and October 15th transplanted onion recorded significantly highest number of coccinellids and thereby found to be better dates of transplanting (Fig. 7).

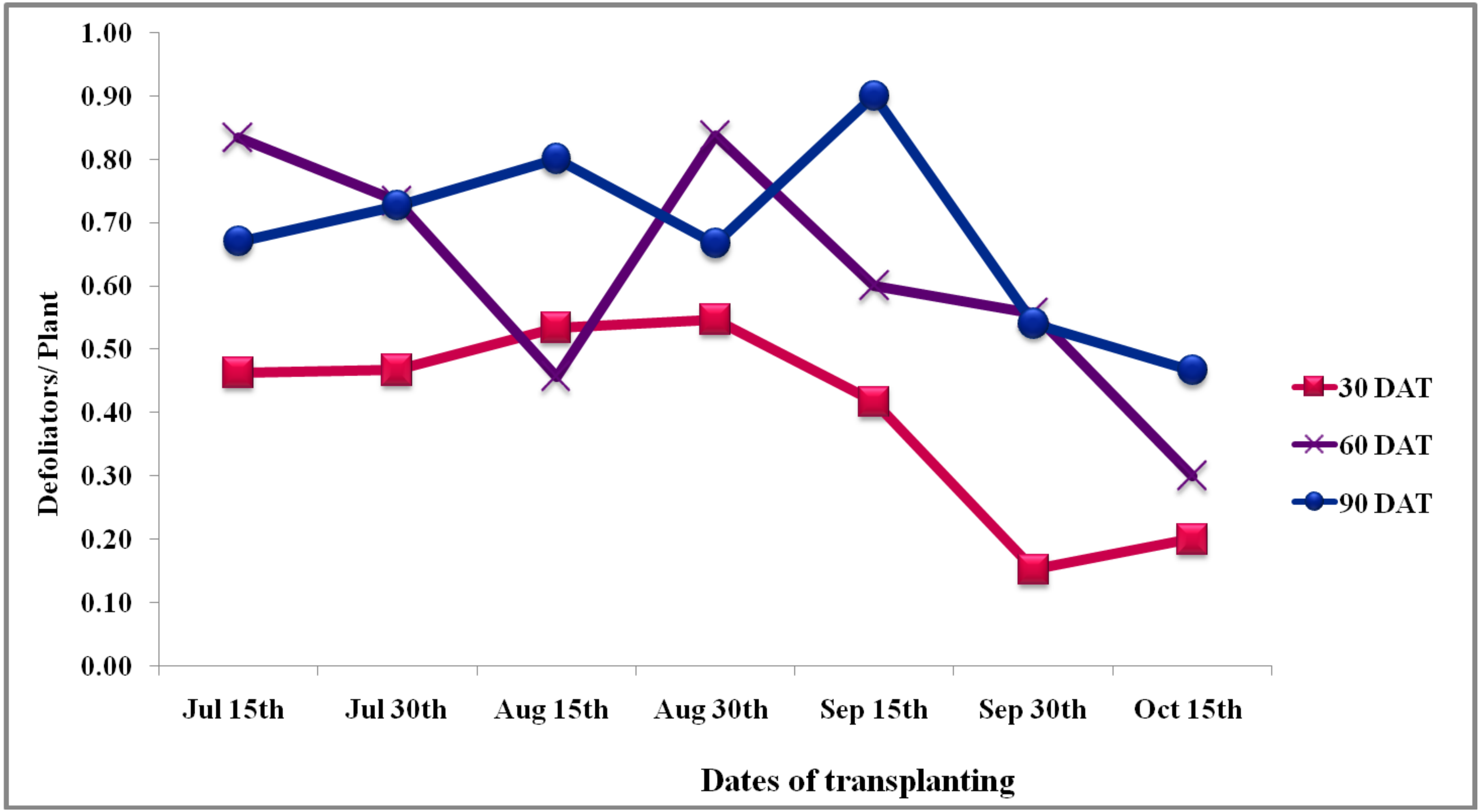


Fig. 6. Influence of different dates of transplanting on defoliators population

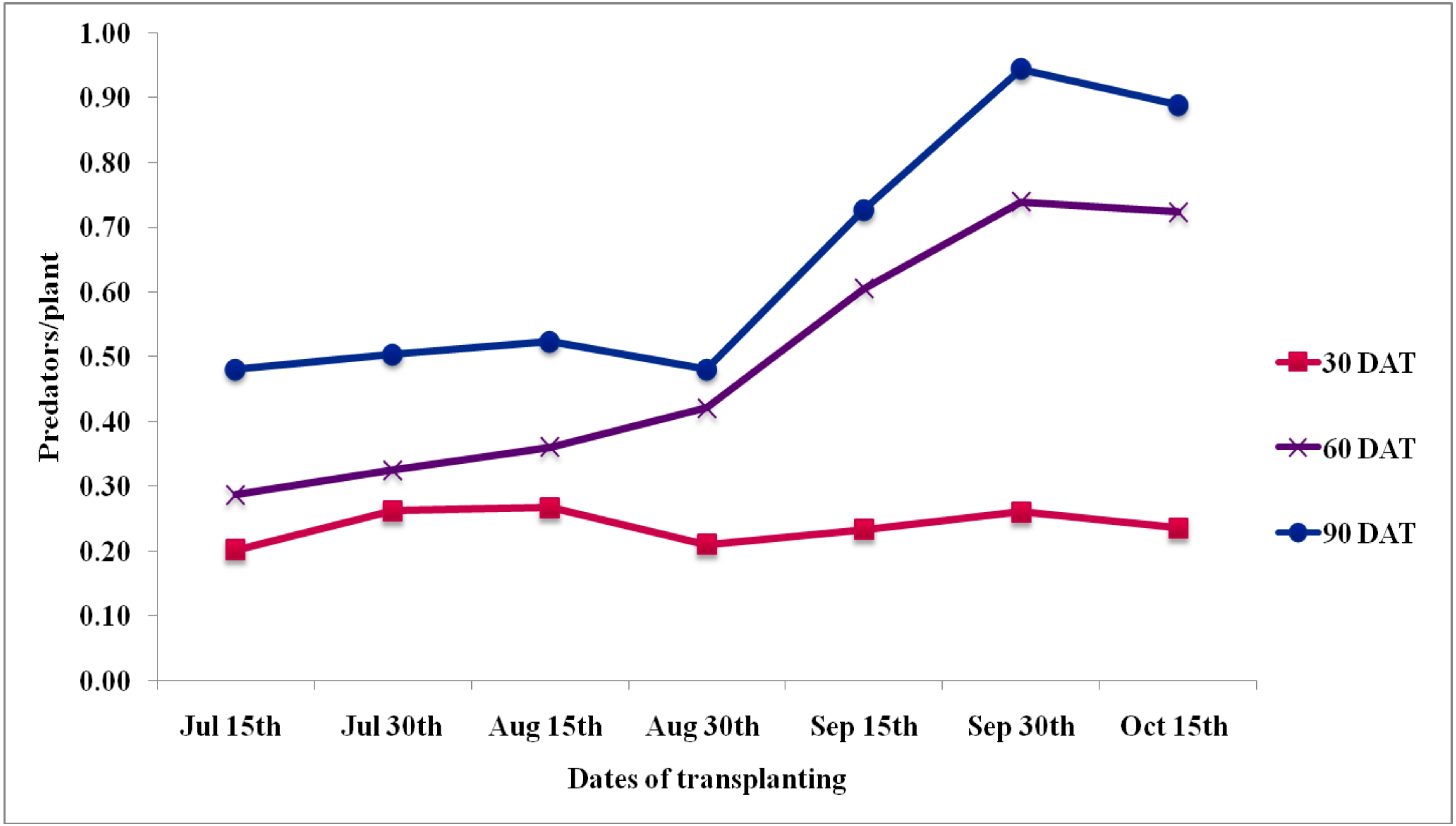


Fig. 7. Influence of different dates of transplanting on natural enemies population.

5.2.3.3 Yield

Onion crop transplanted during September 15th and October 15th recorded significantly higher yield (15.66 and 16.77 t/ha). This high yield may be attributed to low incidence of thrips in early stages of its crop growth (Fig. 8). Similarly, lowest yield in July 15th transplanted crop is because of high incidence of thrips at younger stage of crop (15 DAT). In support of this result Raheja (1973) observed that damage of thrips in early stages of cop growth was more important and likely to result in substantial reduction in yield.

5.3 Optimization of plant protection schedule for management of insect pests of onion

5.3.1 Management of Thrips

A day before spray population of thrips varied between the treatments this was due to seed treatment as well as spraying undertaken in nursery which suppressed the initial population of thrips.

The results of study on optimization of various insecticides for management of thrips revealed that the T_4 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two sprays with thiamethoxam 25 WG @ 0.2 g/l + fipronil 5 SC @ 1 ml/l and one spray of chlorantraniliprole 18.5 SC @ 0.15 ml/l) and T_6 (no seed treatment, followed by one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two sprays with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one sprays with chlorantraniliprole 18.5 SC @ 0.15 ml/l) afforded good control of thrips upto fifteen days after spraying and were superior to all other treatments (Fig. 9 and 10).

Much research works have been conducted with respect to screening of chemicals for thrips individually. But no much effort have been made to use them consecutively or use in the IPM schedule However, not much studies pertaining to optimization of plant protection schedule needed for onion growers. The present findings are comparable with the findings of Gupta *et al.* (2011) evaluated the efficacy of different contact and systemic insecticides against thrips in onion variety Agri and found that sequential spray of deltamethrin @ 0.092 per cent, carbosulfan 25 EC @ 0.2 per cent, fipronil @ 0.1 per cent and thiomethoxam 25 WG @ 0.2 per cent at 15 days interval performed better in reducing thrips population.

Farman *et al.* (2010) reported that the insecticides like Thiodan, Confidor, Tracer and Megamos were effective against thrips (*Thrips tabaci*) on onion. Hosmani *et al.* (2012)

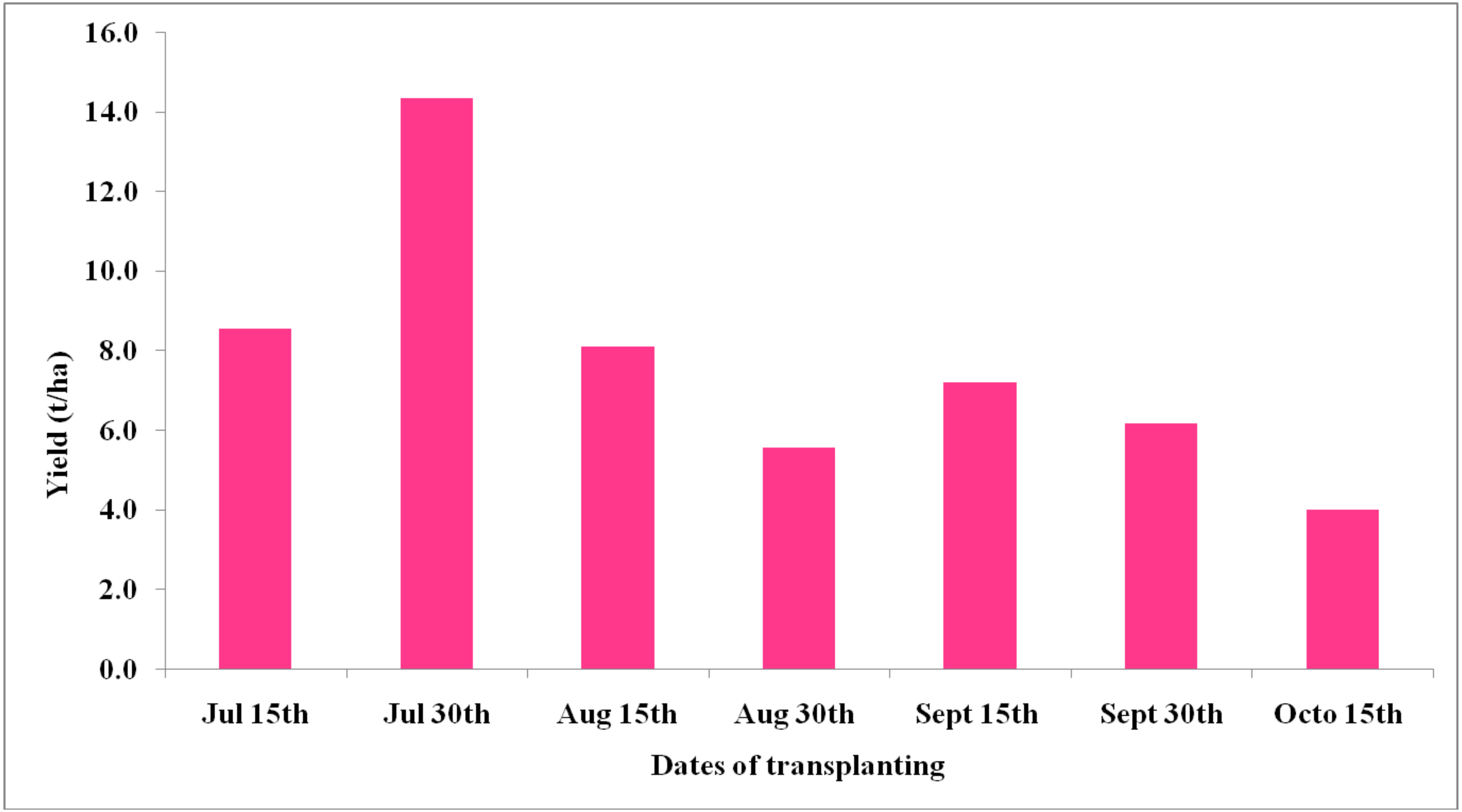


Fig. 8. Influence of different dates of transplanting on bulb yield of onion

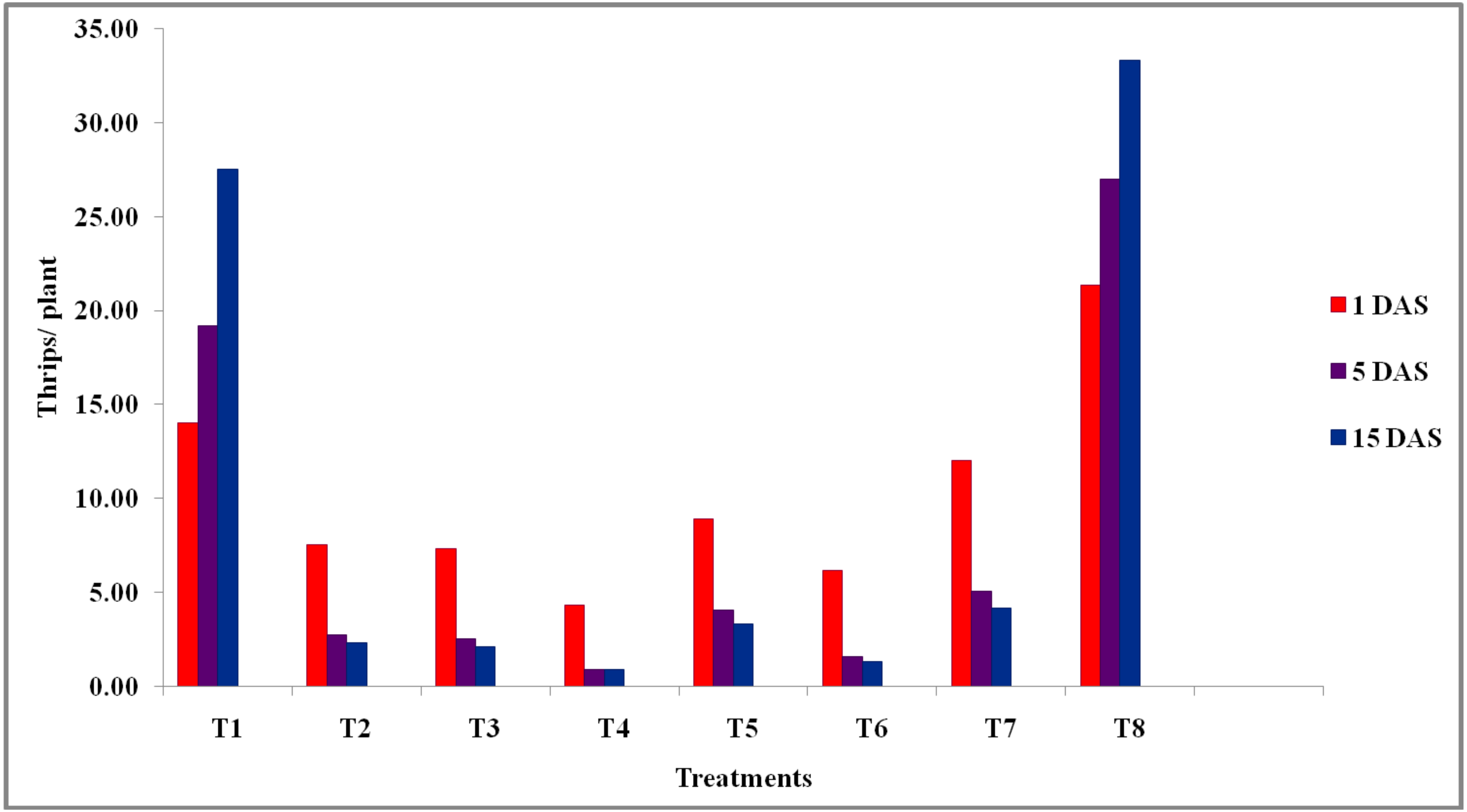


Fig. 9. Optimization of plant protection schedule for the management of *Thrips tabaci* on onion (first spray)

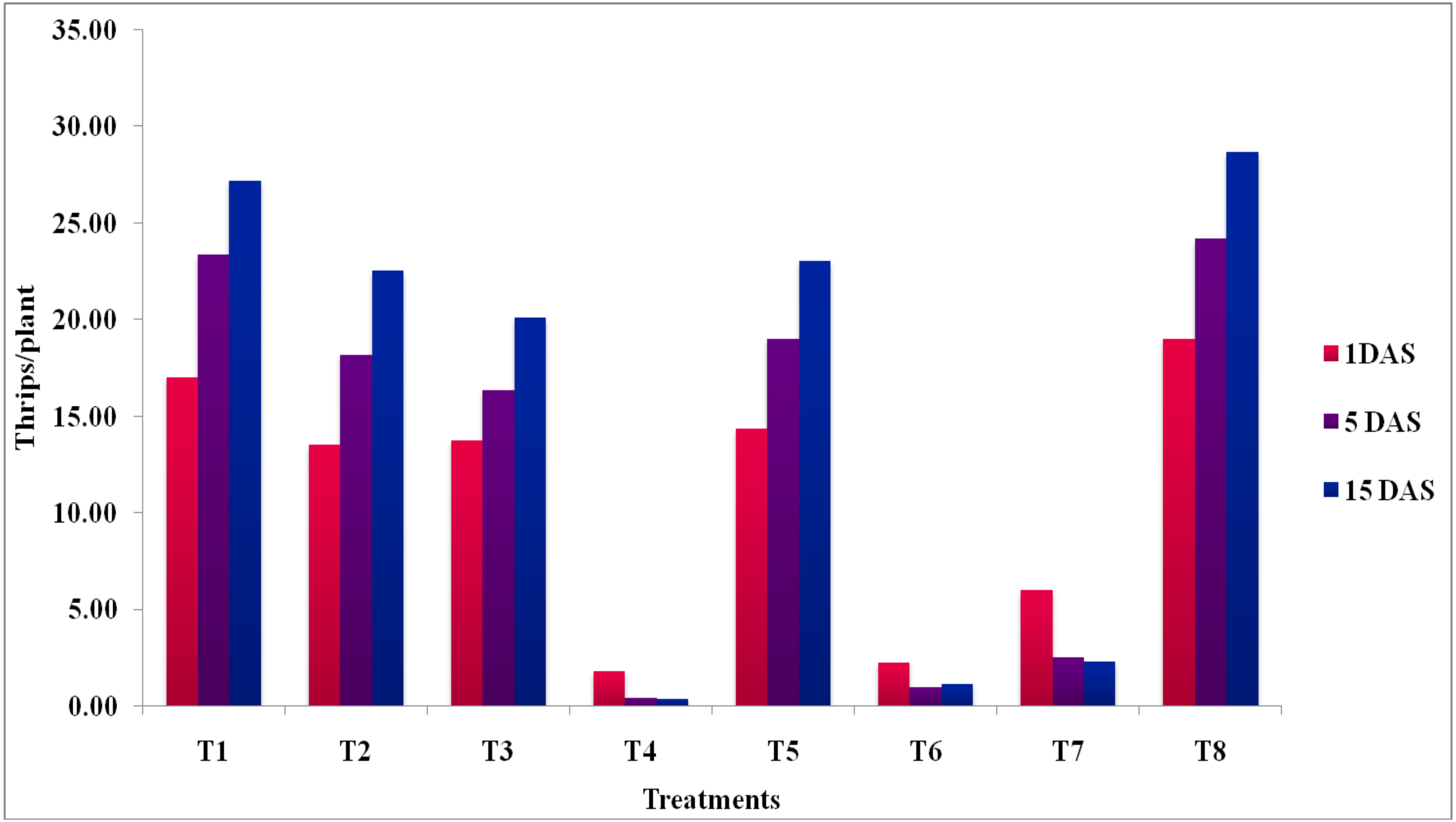


Fig. 10. Optimization of plant protection schedule for the management of *Thrips tabaci* on onion (second spray)

reported that fipronil 80 WG @ 60 g a.i./ha was effective in reducing the thrips population with increased yield of onion. Similarly, Ibrahim and Adesiyun (2010c) evaluated two factors consisting of transplanting date and insecticide frequency and found that transplanting of onion early in season *i.e.,* November combined with two sprays with lambda - cyhalothrin gave better control of thrips with increased yield of onion compared to three to four rounds of application of insecticides.

5.3.2 Management of defoliators

The T_4 treatement consisting (seed treatment with imidachloprid 60 FS @ 9 ml/kg of seed + two sprays with thiamethoxam 25 WG @ 0.2 g/l + fipronil 5 SC @ 1 ml/l and one spray of chlorantraniliprole 18.5 SC @ 0.15 ml/l) and T_6 (no seed treatment, followed by one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two sprays with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one sprays with chlorantraniliprole 18.5 SC @ 0.15 ml/l) were found to be effective in managing the defoliators population in onion (Fig. 11)

The present findings are in line with the findings of Sreenivas *et al*. (2013) evaluated eleven treatments comprising of organic and inorganic treatments and revealed that among all treatments rynaxypyr 20 SC was found to be better treatment followed by lufenuron and spinosad 48 SC.

5.3.3 Influence of insecticide on natural enemies

The spider and coccinellids population was significantly higher in T_1 (seed treatment with imidacloprid 60 FS @ 9 ml/l/kg of seed) and T_8 (untreated control), since here no chemical spray was followed. Hence, there was no significant difference in population of spiders and coccinellids in all other treatments. (Fig. 12 and 13).

5.3.4 Yield

Maximum bulb yield of onion 24.44 t/ha was recorded in T_4 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two sprays with thiamethoxam 25 WG @ 0.2 g/l + fipronil 5 SC @ 1 ml/l and one spray of chlorantraniliprole 18.5 SC @ 0.15 ml/l) (Fig. 14).

5.3.5 Economics of management of pests of onion

The highest benefits costs ratio of 1:13 was obtained in the T_4 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + two spray with thiamethoxam 25 WG @ 0.2 g/l + fipronil 5 SC @ 1 ml/l and one spray of chlorantraniliprole 18.5 SC @ 0.15 ml/l) this was

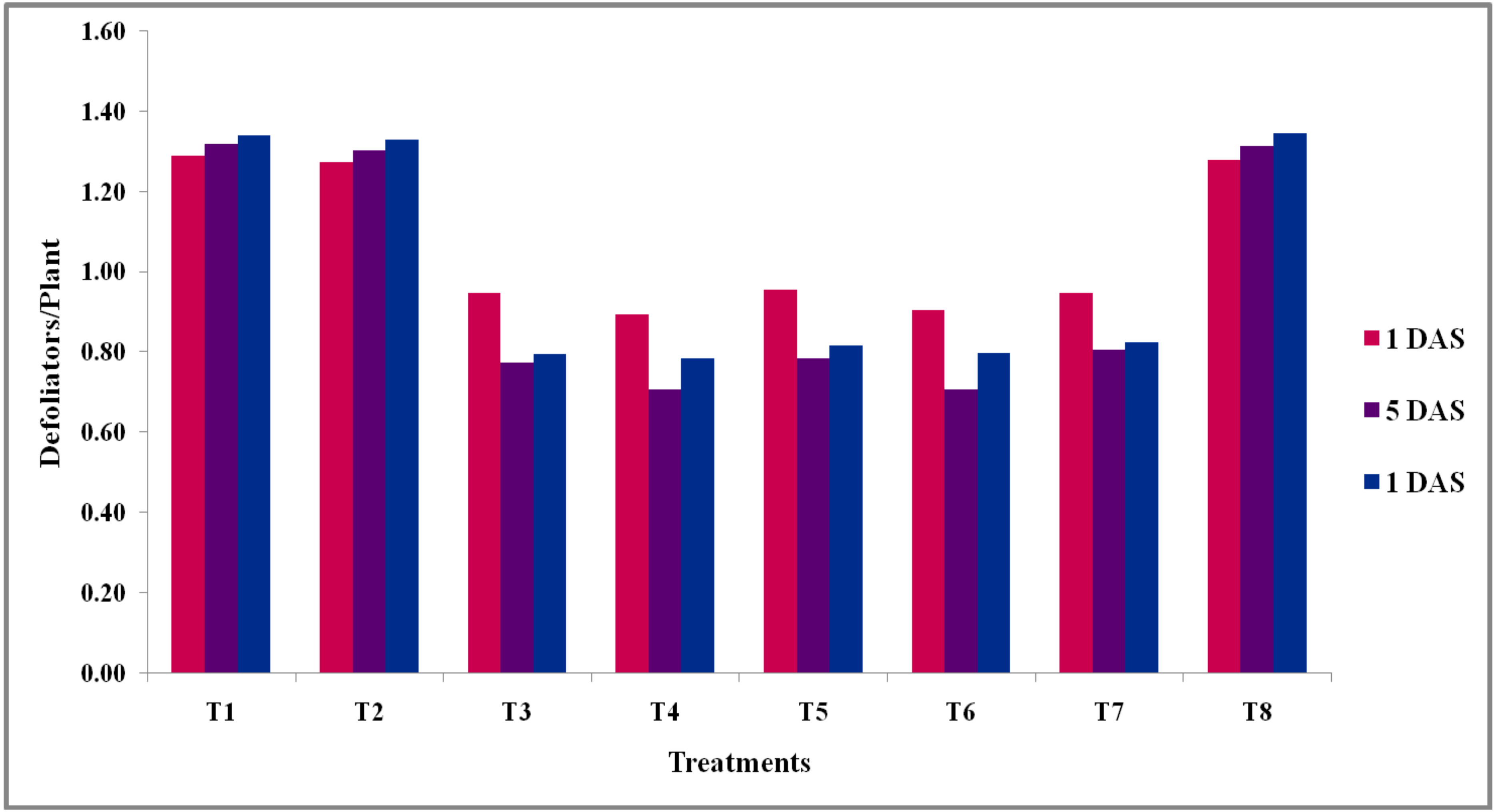


Fig. 11. Optimization of plant protection schedule for the management of defoliators on onion

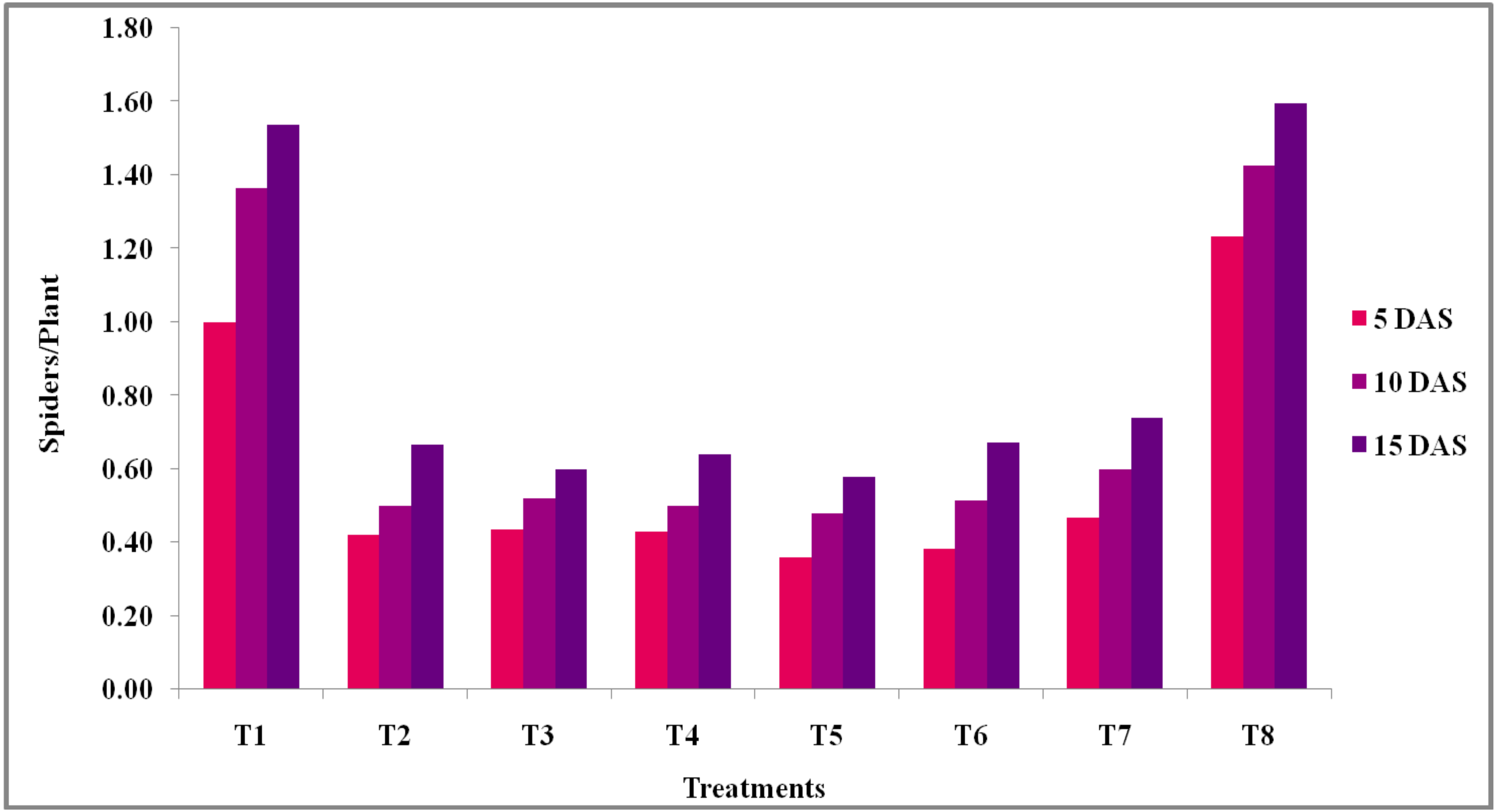


Fig. 12. Effect of plant protection schedule on the population of spiders on onion (first spray)

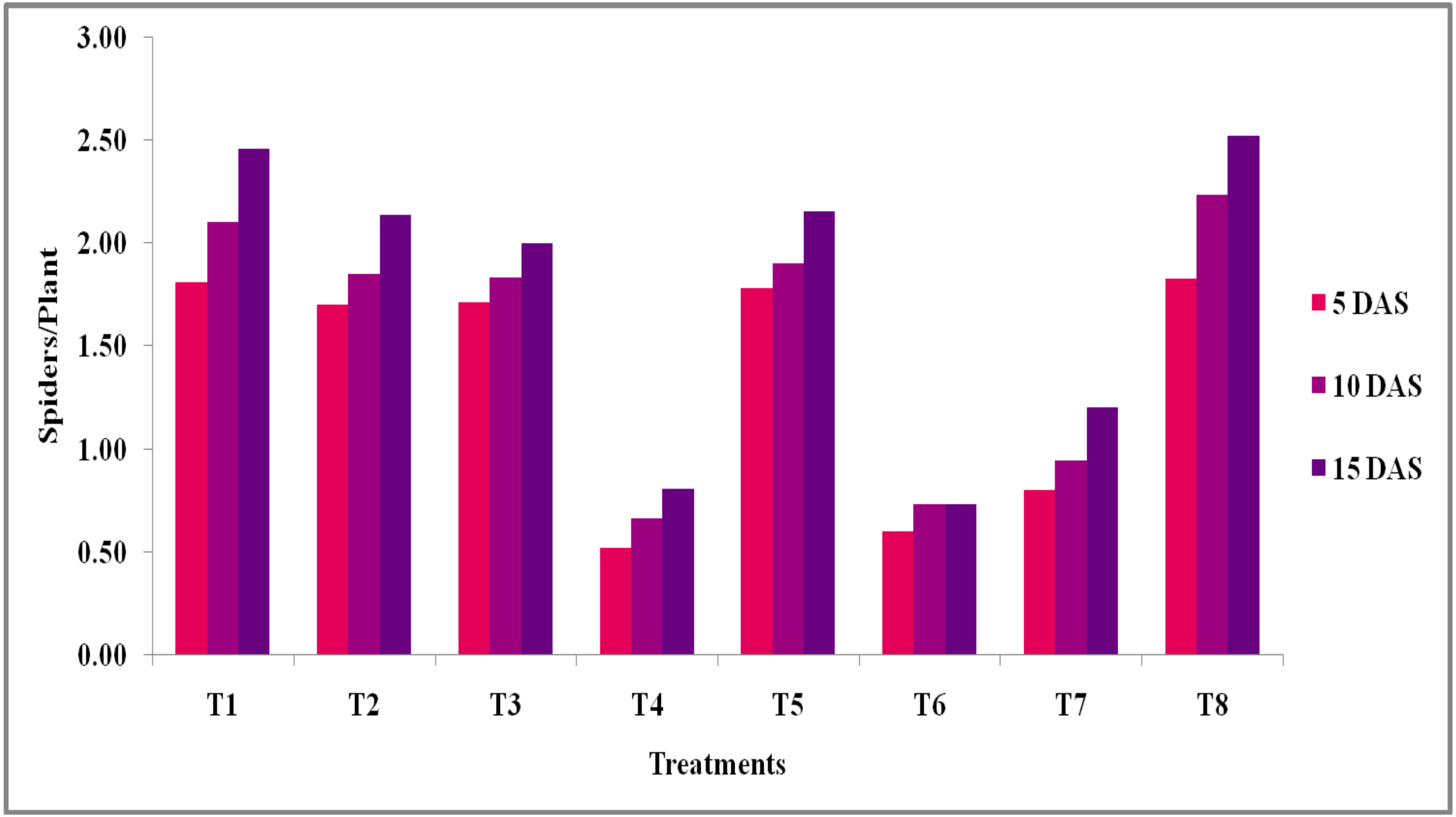


Fig. 13. Effect of plant protection schedule on the population of spiders on onion (second spray)

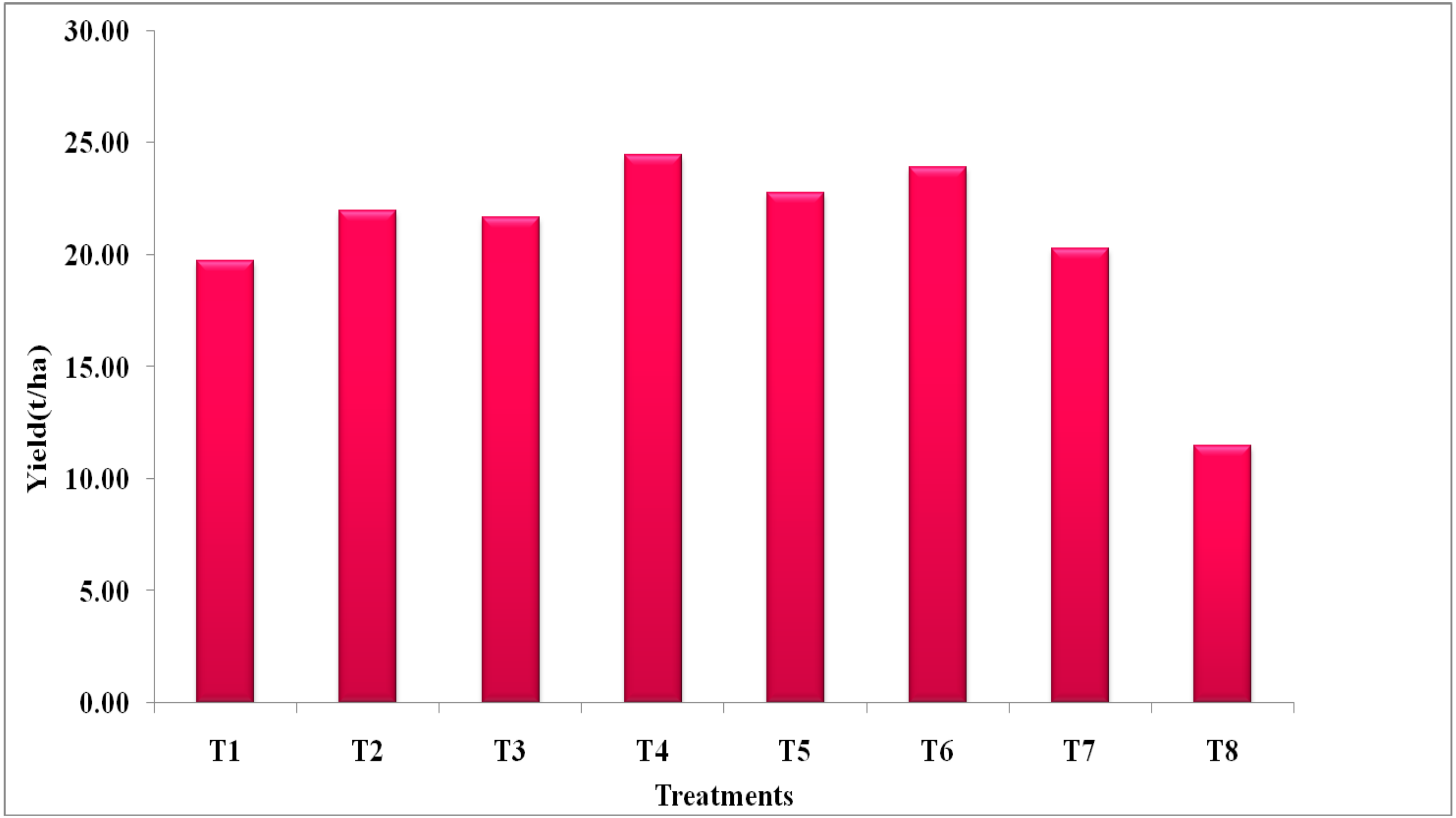


Fig. 14. Optimization of plant protection schedule on the bulb yield of onion

followed by T_6 (no seed treatment, one spray in nursery with imidacloprid 17.8 SL @ 0.3 ml/l and two spray with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l) which was recorded 1:12.

SUMMARY AND CONCLUSIONS

VI. SUMMARY AND CONCLUSIONS

Investigations on the survey, dates of transplanting and management of insect pests of onion using chemicals were undertaken at the Main Agricultural Research Station, University of Agricultural Sciences, Raichur during *kharif* 2012-13.

Survey for the insect pests and their natural enemies was carried out in four district of Hyderabad-Karnataka region. The mean population of thrips and defoliators varied from (10.82 to 26.11 thrips/plant and 0.25 to 4.20 defoliators/plant respectively) in different districts. The maximum population of 26.11 thrips per plant was recorded in Bellary district with a range of 15.88 to 26.11 followed by Gulbarga district (25.77 thrips/plant) with a range of (15.10 to 52.77 thrips/plant) and minimum population of thrips recorded at Raichur (18.38 thrips/plant) and Yadgir (17.10 thrips/plant) district. The highest incidence of defoliators were noticed in Bellary and Yadgir district which varied from 0.70 to 4.20 defoliators per plant. In Raichur and Gulbarga district minimum incidence were recorded and which was ranged from 0.75 to 2.35 defoliators per plant. The spiders and coccinellids population ranged from 0.10 to 0.80 and 0.15 to 0.33 per plant respectively in different district surveyed.

Studies on the dates of transplanting on insect pests of onion revealed that the peak activity of *T. tabaci* on onion was noticed from onion transplanted during July 15th which recording highest population of 21.59 thrips per plant followed by August 15th (20.87 thrips/plant) and July 30th (20.54 thrips/plant). However, minimum population was recorded on the crop transplanted during October 15th (13.37 thrips/plant) and September 30th (15.44 thrips/plant) and which were found to be optimum dates of transplanting. Whereas, highest incidence of defoliators was noticed in August 30th, July 30th, September 15th and August 15th transplanting (0.81, 0.76, 0.71 and 0.67 defoliators/plant) and minimum incidence (0.31 and 0.44 defoliators/plant) was registered on October 15th and September 30th dates of transplanting. Maximum natural enemies population *viz.,* spiders and coccinellids were noticed in onion transplanted during September and October. Highest yield of 16.7 t/ha were obtained in the October 15th transplanted onion.

Studied carried out in respect of standardizing optimum plant protection schedule for onion pests management has resulted that treatment encompassing seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed followed by two sprays with thiamethoxam 25 WG @ 0.2 g/l and fipronil 5 SC @ 1 ml/l for thrips and one spray of chlorantraniliprole 18.5 SC @ 0.15 ml/l for defoliators and T_6 (no seed treatment, one spray in nursery with imidacloprid

17.8 SL @ 0.3 ml/l and two sprays with fipronil 5 SC @ 1 ml/l and thiamethoxam @ 0.2 g/l and one sprays with chlorantraniliprole 18.5 SC @ 0.15 ml/l) afforded good control of thrips upto fifteen days after spraying and were superior to all other treatments and also were found to be effective in reducing the defoliators. This was followed by T_3 (seed treatment with imidacloprid 60 FS @ 9 ml/kg of seed + one spray with fipronil 5 SC @ 1 ml/l + one spray with chlorantraniliprole 18.5 SC @ 0.15 ml/l.). Highest yield of (24.4 and 23.8 t/ha) and B:C ratio of (1:13 and 1:12) were obtained in T_4 and T_6 treatment.

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VII. REFERENCES

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APPENDIX

APPENDIX – I

Fortnightly average weather data from July to January 2012-13

Fortnight	Temperature (^{o}C)		Rainfall (mm)	Number of rainy days
	Maximum	Minimum		
July I FN	32	22	16	1
July II FN	32	22	88	5
August I FN	33	22	0	2
August II FN	31	21	50	7
September I FN	33	21	92	2
September II FN	32	19	34	4
October I FN	33	18	45	0
October II FN	31	17	37	3
November IFN	32	17	0	0
November II FN	33	16	0	0
December I FN	31	15	0	0
December II FN	34	16	0	0
January I FN	32	19	0	0