



ISSN (E): 2277- 7695  
ISSN (P): 2349-8242  
NAAS Rating: 5.23  
TPI 2021; 10(12): 1741-1748  
© 2021 TPI

[www.thepharmajournal.com](http://www.thepharmajournal.com)

Received: 14-09-2021

Accepted: 29-11-2021

#### **Pesaralanka Vysali**

Department of Computer Science and Engineering, Koneru Lakshmaiah Educational Foundation, Vaddeswaram, Guntur, Andhra Pradesh India

#### **Kodukula Subramanyam**

Department of Computer Science and Engineering, Koneru Lakshmaiah Educational Foundation, Vaddeswaram, Guntur, Andhra Pradesh India

#### **Indra Kumar Kasi**

Department of Entomology, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Himachal Pradesh, India

#### **Corresponding Author:**

#### **Pesaralanka Vysali**

Department of Computer Science and Engineering, Koneru Lakshmaiah Educational Foundation, Vaddeswaram, Guntur, Andhra Pradesh India

## **A study on the management of biotic and abiotic threats in chilli crop cultivation**

**Pesaralanka Vysali, Kodukula Subramanyam and Indra Kumar Kasi**

#### **Abstract**

Chilli is one among the important commercial spices. It has a significant demand in the market because of its use in day-to-day life. Cultivation of chilli has its own difficulties because of the biotic (insects & diseases) and abiotic (water related problems & nutrient related problems) threats. For managing both the threats, it requires an integrated approach for making it smooth and affordable. Excess irrigation leads to the vigorous growth of weeds and pests. It can be controlled by opting for drip irrigation which can save water up to 62% and inclines the yield up to 43% in chilli. Nutrient deficiency also can be threat to the crop. It has to be maintained by providing the appropriate fertilizers with recommended dosage. Combined application of organic manures (FYM, poultry manure, neem cake) and inorganic manures along with bio fertilisers (Azospirillum, Phosphobacteria) help the growth and yield of the chilli crop by enhancing the nutritive uptake. Biotic threats (insects & diseases) can be maintained by the mixed approach of management practices viz., crop rotation, installation of traps (yellow sticky, blue sticky and pheromone), planting the border crops (maize, sorghum), botanicals application (Neem cake, neem oil) and minimal toxic chemicals can effectively control the pest population in chilli. Leaf curl virus is the fatal disease which can only be prevented rather than managed. For rest of the fungal diseases (Anthracnose, Cercospora leaf spot) biocontrol control agents like *Trichoderma* spp. can effectively control the diseases. This review paper is the baseline work of future DST-SEED project at Guntur, Andhra Pradesh India.

**Keywords:** Chilli, threats, Drip irrigation

#### **Introduction**

Chilli which is otherwise called Wonder spice or Universal spice originated from South Central America. Chillies are cultivated in almost every part of the world viz., Mexico, Africa, India, Japan, USA etc. Portuguese introduced the chilli to India. India produces 40% of total chilli production in the world. India which is considered “the home of spices” produces chillies practically every season because of the suitable climate conditions, soil properties, irrigation facilities and intensive practices followed by farmers. According to the 2019-2020 estimate, the total area under chilli production in India was 682.58ha and produced an average chilli yield of 2494kg/ha. (National Horticultural Board, 2019-2020). According to FAO 2018 report, 21% of the total produced dry chillies in India were exported to other countries. Majorly chilli producing states in India are Andhra Pradesh, Karnataka, West Bengal, Madhya Pradesh, Maharashtra and Tamil Nadu. Chillies are mainly consumed in the form of chutneys, pickles, curries etc. (Singh, 2020) [76, 77].

Based on the utility, different varieties are cultivated differing in flavour, pungency and colour. Chillies are a good source of nutrients like Vitamin A, Vitamin C, Vitamin B6, Potassium, Iron and Magnesium. Vitamin C was noticeably high in green chillies than in red chillies. (Sparkby, 2006) [81] Small scale farmers consider chilli crops as assuredly beneficial crops. (Patil *et al.*, 2014) [59] For the cultivation of chilli, factors required are proper soil conditions with drainage facility, warm climatic conditions, disease free seeds and water sources. Varieties which are popular in India are Guntur Sannam, Bydagi, Kashmiri chilli, Jwala, Nalchetti, Hindpur and Sattur. However, problems for chilli cultivation faced by farmers likewise high labour charges, high cost of agricultural inputs, the low market price of chilli, pests and diseases, electricity problem. (Naik *et al.*, 2019) [51]. For overcoming the problems in chilli cultivation it requires a particular approach for understanding the situation and factors influencing the Major biotic threats to chilli cultivation are Insects (thrips, whiteflies, aphids, *Helicoverpa* spp.), Mites (yellow mite, broad mite), Diseases (damping-off, choenophora blight, anthracnose, bacterial leaf spot and leaf curl virus) and root-knot

nematodes. Major Abiotic threats can be listed as nutrient deficiency, water deficiency etc. Successful chilli cultivation must have an integrated approach of all nutrient, water, insect and disease management that can overcome both the biotic & abiotic threats effectively. This paper contains a review of all the four management approaches listed in a single paper for profitable chilli cultivation. Mentioned approaches for better management of abiotic and biotic threats in chilli will be evaluated in future project (DST-SEED) which is being carried out at Piduguralla, Guntur, Andhra Pradesh (2021-2022).

## Management of abiotic & biotic threats

### Nutrient Management

Every crop requires essential nutrients for achieving good growth and yield. These nutrients are given in the form of manures either organic or inorganic. Organic manures include poultry manure, farm yard manure, neem cake etc. Inorganic manures include Urea, Murate of Potash, Single Super Phosphate etc. Several studies suggest that organic manures can help the soil for better nutrient uptake, yield and quality. Anitha, 1997<sup>[4]</sup> reported that application of poultry manure enhanced the nutrient availability and gave better growth and yield in chilli. Neem cake application inclined the plant height, number of branches and also dry matter accumulation in chilli plants. (Sharu, 2000)<sup>[72]</sup> Vermicompost alone also gave best results in chilli in terms of growth and yield (Hiranmai and Vijayakumari, 2003)<sup>[26]</sup>. Soreng and Kerketta, 2017<sup>[79]</sup> reported that 100% poultry manure application gave maximum growth than control in chilli. Kurubetta *et al.*, 2017<sup>[41]</sup> demonstrated that application of jeevamurta at transplanting, flowering, fruit initiation stages @ 550 litres/ha has recorded highest dry chilli yield (910 kg/ha) compare to other treatments. Organic manures not only increased the quality of chilli plants but also helped in declining the environmental pollution.

Whereas the application of inorganic fertilizers is considered as costly process and also causes environmental deterioration. Anyhow, few researchers claimed that best results were obtained after the application of inorganic fertilizers alone. Combination of 100 (N):90 (P<sub>2</sub>O<sub>5</sub>):90 (K<sub>2</sub>O): 20 (S):2 (Zn) kg/ha favoured the fresh chilli yield up to 20.57 tonnes/ha for two successive years (1996-1998). (Nirmal *et al.*, 2003)<sup>[54]</sup> Application of 180 kg N/ha and 50 kg K/ha gave the highest yield up to 8.83 tons /ha. (Khan *et al.*, 2014)<sup>[35]</sup> Application of inorganic fertilizers alone caused the imbalance of soil properties that resulted in low yield and high loss. This is very much key component to consider about the application of organic manures and inorganic manures alone. Few researchers affirmed that organic manures didn't change the plant height of chilli but the chlorophyll content and biomass content was high in organic fertilizer treated plants when compared to inorganic fertilizers treated plants. After the concern of the issues with both organic & inorganic manures, a new approach came into line i.e., combination of both organic manures & inorganic manures. Combination of both organic and inorganic manures increased the uptake of nitrogen when compared with organic manures alone. (Shashidhara, 2000; Kattamani, 2004)<sup>[73, 32]</sup> but can also favour the nutrient uptake efficiency. (Ghosh *et al.*, 2015)<sup>[22]</sup> 13-20% increase in the yield of vegetables was observed when treated with Microbial consortium which fixes N, P and Zn solubilizing bacteria also deducted the use of 25-30% fertilizers. (Magdoff and Van, 2000)<sup>[43]</sup> Rao *et al.*, 2015<sup>[61]</sup>

revealed that application of vermicompost, panchagavya, azospirillum and phosphobacteria reduced the flower drop and inclined the yield in chilli. Application of RFD 75% + Farmyard manure + Sheep manure + Poultry manure + Vermicompost + Biofertilizers gave highest returns with BC ratio (4.47) in chilli. (Shabir *et al.*, 2017)<sup>[71]</sup> FYM @ 20 tonnes/ha applied along with 100% substitution of recommended dose of N (75 kg /ha) in organic form recorded maximum plant height, branches, and root spread. (Akshay *et al.*, 2018) Nchang *et al.*, 2018 depicted that 50% NPK, 50% FYM along with biofertilizers gave pod yield up to 194 quintals /ha in chilli. Application of 50% Urea, 50% Vermicompost and 50% FYM favoured the seedling growth to maximum when compared to control. (Mishra and Dayal, 2018) Kumar *et al.*, 2019<sup>[37, 38]</sup> found that combination of 120:60:50 of NPK +25tonnes FYM + Azospirillum/ha gave maximum plant height of 50cm, with 14 branches and 73 no. of leaves/plant in Andhra Jyothi G5 variety chilli. Shinde, 2020<sup>[75]</sup> experimented the effect of seasol (seaweed biofertilizer) on chilli. His findings revealed that seasol @ 0.25% gave maximum yield.

Combination of NPK along with Poultry manure and biofertilizer (*Saccharomyces cerevisiae*) benefitted the chilli cultivation with better growth and higher yield. (Rivitra *et al.*, 2021)<sup>[64]</sup> Thus, biofertilizers (Azospirillum, Phiosphobacteria, Seasol & *Saccharomyces cerevisiae*) also played keen role in the nutrient management for attaining best benefit cost ratio in chilli. Many researches are being carried out in terms of different factors like dosage of manures Pariari and Khan, 2013<sup>[58]</sup> experimented on the different organic manures with different doses to find out the best combination. Their results depicted that 50% N from vermicompost + 50% N from urea gave the maximum yield i.e., 8.65 t/ha where as 75% N from neem cake and 25%N from urea gave the best quality chilli with ascorbic acid (177.60mg100-1g), Capsaicin (114.20 mg100-1g) contents. Wahoco *et al.*, 2016<sup>[94]</sup> studied about the effect of N levels in growth and yield of chilli, 250kg/ha N gave maximum plant height 69.6cm and also maximum no. of fruits per individual plant (163.66) but their findings also proved that there is no significant difference in the growth & yield of chilli treated with 250kg/ha and 150kg/ha & Application of organic manures at 2X (265.4 kg/ha) favoured the growth parameters of chilli plants but yield was better at 1X (132.7 kg/ha). (Wahoco *et al.*, 2016; Khaitov *et al.*, 2019)<sup>[94, 34]</sup>

Method of applying the manures (Vermicompost applied with vermiwash & water in 1:1 ratio inclined the dry chilli yield. (Geroge, 2006)<sup>[21]</sup> Experimental findings revealed that organic manures (Vermicompost @ 2.5 tonnes/ha +FYM @ 12.5 tonnes/ha) when applied at basal dose achieved the maximum growth and yield when compared to control plots. (Reddy *et al.*, 2017)<sup>[62]</sup> and also novel products like Higrow which is supplement for macro and micro nutrients when sprayed at 7ml/litre of water gave the best results in terms of growth and yield of chilli as follows 67.86 cm plant height, 117.20 fruits per individual plant. (Baloch *et al.*, 2008)<sup>[9]</sup> Deore *et al.*, 2010<sup>[17]</sup> developed a novel organic fertilizer which is made up of rice straw, neem cake, FYM, poultry waste, fish waste, press mud, rock phosphate and basalt dust. Micronutrients (Cu, Zn, Mg, Mn, Fe) and B were added separately as seed amino acid. This novel organic fertilizer at 3% dosage depicted the maximum growth and maximum yield in chilli. Aminochelates can be used as substitutes to synthetic fertilizers that excel the seedling growth at reduced

transplant growth period. (Souri and Sooraki, 2019) <sup>[80]</sup>. Overtime, an extensive literature has developed on the nutrient management of different crops as Integrated nutrient management which mainly focused on the fulfilment of nutrients to the crop precisely with novelty. Several products are reported in the literature to address this issue.

### Water Management

Water plays crucial role in the plant development which can affect the quality and quantity of the produce. Proper amount of water supplied to the crop with accurate efficiency can also reduce the cost of cultivation. Resource management is the major concern at recent times and water management can directly affect the crop's health. Excess water can increase the chance of susceptibility to pests and diseases which can also favours the weed growth. Types of irrigation can be classified into two 1. Macro irrigation (surface, flood) 2. Micro irrigation (drip, sprinkler).

### Surface irrigation

Excessive amount of water was utilised in surface irrigation when compared to drip irrigation. (Ashwani *et al.*, 2020) <sup>[6]</sup>.

### Drip irrigation

Drip irrigation minimizes the deep percolation, helps to reduce water wastage at initial stages of crop and reduces the evaporation till the harvest stage. (Kumar *et al.*, 2011) <sup>[39, 40]</sup> Drip irrigation in chilli favoured 62% water saving and 44% incline in yield. Anon. (2018) <sup>[5]</sup>. Drip irrigation installed in chilli field increased the yield up to 48% and water consumption declined by 50% but when installed with mulch gave different results i.e., yield (32↑) & water consumption (28↓). (Nijamudeen and Dharmasena, 2002) <sup>[53]</sup> Drip irrigation noticeably increased the yield of chilli from 10-30% and saved water upto 43%. (Ashwani *et al.*, 2020) <sup>[6]</sup> Drip irrigation alone undoubtedly benefitted the chilli farmers with good yield and returns. A closer look to the literature on fertigation schedules in chilli. however, reveals that a number of gaps and short comings. the dosage of the fertilizers used in the drip, selection of fertilizers to be used and plan of schedule for the nutrient requirements must be addressed and more research has to be done to fulfil the different varieties of chillies cultivated. Seminal contributions on fertigation of chilli plants have been made by Deolankar and Firake, 1999 <sup>[16]</sup> worked on the fertigation method in chilli.

Their study was to provide the soluble solid fertilizers through the fertigation process and recorded the growth parameters accordingly. However, the plant growth was higher in 125% RDSF with recorded plant height (89.70cm) followed by 100% RDSF with recorded plant height (87.04cm). Veerana *et al.*, 2000 <sup>[91]</sup> presented in *Conf. on Spices and aromatic plants* about the cultivation of chilli through fertigation gave higher yield than the conventional cultivation and their findings in the next successive year revealed that 80% RDF through drip fertigation gave up to 1268kg/ha dry chilli yield which was presented at *Changing scenario in the production systems of horticultural crops. Proceedings National Seminar* (2001) at Coimbatore, Tamil Nadu, India. Tumbare and Bhoite, 2002 <sup>[88]</sup> recorded the highest yield in the cultivation of chilli through 100% RDF by drip irrigation with recorded benefit cost ratio as 2.17 when compared with normal surface irrigation. Tumbare and Nikam, 2004 <sup>[87]</sup> recorded the higher yield up to 9.18 tonnes/ha through fertigation method in chilli. Irrigation was provided once for every two days with RDF

was the possible reason for such yield. Selva Kumar, 2006 studies revealed that benefit cost ratio reached up to 3.30 in chilli with combination of 100% WRc (computed water requirement of crop) + 100% RDF through fertigation. Muralikrishnasamy *et al.*, 2006 <sup>[49]</sup> reported that dry chilli yield was higher in drip fertigation method (50% pan evaporation + 100% N& K) as 2222kilos/ha but the surface irrigation combined with NPK soil application gave 1327kilos/ha dry chilli yield. Mahajan *et al.*, 2007 <sup>[44]</sup> studies revealed that 100% RDN (recommended dose of nitrogen) when supplied through drip irrigation (277.4 quintals/ha) gave superior yield when compared with check basin irrigation (216.1 quintals/ha) in chilli. Vijaykumar *et al.*, 2010 treatment with 75% Pan evaporation+ 75% RD of N & K inclined the growth & yield of chilli when provided water for 5 days in a week at 50% Evapo transpiration. Chilli's BC ratio was 3.8 under drip irrigation with 1 lateral for each row on the raise bed conditions. (Nadiya *et al.*, 2013) <sup>[50]</sup> Ashwani *et al.*, 2020 <sup>[6]</sup> depicted the highest yield of chilli i.e., 10.69 tonnes/ha was produced through daily drip irrigation with 125% RDN and marginal saline water. Highest BC ratio was obtained by when treated with 80% Irrigation Water Requirement +100% RDF in chilli cultivation. (Gireesh *et al.*, 2020) <sup>[24]</sup>

In short literature pertaining to above researchers strongly suggests that drip irrigation can be efficient water management strategy for cultivation of chilli with minimal water usage, incline in the yield and cut short the inputs for chilli cultivation. This can also be more efficient when fertilizers are supplied through drip at exact doses but more research has to be done when it comes for fertigation dosages, schedules to achieve the best results. Limitations persists when it comes to quality of water and available of water resource, adoption to the technology and also capital cost.

### Insect Management

Main pests of chilli are aphids (*Myzus persicae* & *Aphis gossypii*), mites (*Polyphagotarsonemus latus*), thrips (*Scirtothrips dorsalis*) and whitefly (*Bemisia tabaci*). (Berke and Shieh, 2000) <sup>[10]</sup> They cause very drastic economic loss to the chilli farmers when affected. Few more pests also infest the chilli crop viz., *Helicoverpa armigera*, *Tobacco caterpillar* etc. Prevention and early identification can diagnose the infestation up to remarkable level. For the instance, the following studies were conducted on the insect pest management of chilli.

### Thrips

Basic symptom for the thrips infestation is upward curling of leaves due to sucking of cell sap by adults & larvae of thrips. (Sanap and Nawale, 1987) <sup>[65]</sup> But at heavy infestation leaves become tender and buds turn out to brittle which leads to shedding of leaves and yield loss that can appear as chilli leaf curl disease. (Amin, 1979) <sup>[3]</sup> Chilli thrips infestation causes silvery leaf surface, leaf lamina thickening, brown frass markings on leaves, petiole and fruits, ring like scarred tissue around the apex of fruits and distorted fruits with premature falling of leaves. (EPPO, 2005) <sup>[20]</sup> Mahalingappa *et al.*, 2008 <sup>[45]</sup> evaluated few chemicals against mites and thrips in chilli. Results revealed that Profenofos@ 0.10% was most effective against mite infestation. Thrips population was effectively controlled by fipronil @ 0.01% and triazophos@ 0.08% than ethion, cypermethrin and chloropyrifos. Mandi and Senapati, 2009 <sup>[46]</sup> reported that use of acetamidrid gave highest yield (40.5quintals/ha) with highest cost benefit ratio



1:16.97 by controlling thrips infestation. Fipronil @ 50gm ai./ha recorded least% of thrips in chilli with no phytotoxic effects in chilli but fipronil @ 30gm ai./ha gave poor control. (Reddy and Sreehari, 2009) [63] Prabhu *et al.*, 2015 revealed that Imidacloprid 17.8% SL effectively managed chilli thrips population 250 ml/ha with 25% increase in green chilli yield. Chlorphenapyr + White sticky trap treated plots recorded least percentage infestation of upward curl (19.05%) and downward curl (21.08%) while the control plot recorded highest percentage of upward curl (71.25%) and downward curl (82.38%) in chilli. (Hossain *et al.*, 2016) [27] Devi *et al.*, 2017 [19] demonstrated that least infestation of thrips and mites was found after the application of organic manures *viz.*, vermicompost and neem cake. Thrips population was controlled by spinosad@0.015% and got yield up to 272.33 quintals/ha. (Devi *et al.*, 2017; Seal *et al.*, 2006; Meena and Tayde, 2017) [19, 67, 47] Dale and Borden, 2018 reported that Chlorantraniliprole controlled the chilli thrips population with minimal risk to natural enemies.

### Mites

Border crops *viz.*, maize, agathi and sunflower were reported as best barrier crops against mites in chilli. (Nelson and Natarajan, 1994) [52] Ahmed *et al.*, 2001 [2] studies revealed that neem oil application @ 5ml/litre recorded 34.2% reduction of chilli mite over control. Combined application of (Neem cake+ vermicompost+50% NPK) recorded higher yield and least infestation of thrips and mites in chilli. (Varghase, 2003; Giraddi and Smitha, 2004) [89, 23] Mite population was high from Mid- September to Mid -October in chilli. (Vichitbandha and Chandrapatya, 2011) Bio efficacy of acaricides (dicofol) inclined when mixed with plant oils. (Veena *et al.*, 2017) [90] Combination of Fipronil 5% + Buprofezin 20% SC @ 100+400g a.i./ha has recorded the lowest number of chilli mite population. (Kumar *et al.*, 2019) [37, 38] Combination of spirotetramat + diafenthiuron @ 75+300g a.i./ha recorded least mite incidence as compared to other treatments. (Kotresh *et al.*, 2020) [36].

### Whiteflies & Aphids

White flies suck the cell sap from leaves causing yellowing and crumpling which eventually causes stunted growth and distorted fruits. (Sani *et al.*, 2020) [66] Planting border crops *i.e.*, South African tall maize (SATM) (3 rows thick all along the main crop) controlled the sucking pest infestation and gave higher yields. (Gundannavar *et al.*, 2010; Tatagar *et al.*, 2011; Sujay *et al.*, 2015) [25, 85, 83] Sucking pest incidence in chilli was lowest when intercropped with coriander, cotton and onion that claimed higher yields in chilli. (Aswathanarayanareddy *et al.*, 2006) [7] Maize and brinjal when intercropped with chilli reduced the aphid incidence in chilli. (Hussein and Samad, 1993) [29] Bio efficacy of chlorfenapyr 240 SC, emamectin benzoate 5% SG and imidacloprid 17.8 SL was evaluated on the control of white fly population in chilli. Their studies revealed that maximum yield obtained in the plots treated with chlorfenapyr 240 SC but BC ratio was high in emamectin benzoate 5% SG treated plots. (Jain *et al.*, 2018) [30] Chemical treatments with systemic insecticides *viz.*, clothianidin, dinotefuran, imidacloprid, thiamethoxam, chlorantraniliprole, spinosad, and flupyrifurone has better control over the white fly population. (Shindhe *et al.*, 2016; Avery *et al.*, 2019) [8]; Smith *et al.*, 2019) Entomopathogenic fungi *viz.*, *Beauveria bassiana* and *Metarhizium anisopliae* can effectively control

the white fly population as symbiotic endophytes and considered as future strategy in IPM. (Sani *et al.*, 2020) [66] Bio rationals *viz.*, *Beauveria bassiana*, *Lecanicillium lecanii* & *Metarhizium anisopliae* not only reduced the white fly population but also controlled the aphid population in capsicum. (Singh and Josh, 2020) [76, 77].

In addition, these findings provide information about the idea of controlling the major pests in chilli in an integrated manner. Agronomic practices like crop rotation, deep ploughing, weed control, proper spacing, destroying debris and planting border crops can collectively prevent the infestation of almost all pests in chilli. Botanical extracts like neem seed extract, neem cake and Entomopathogens like *Beauveria bassiana*, *Verticillium lecanii* at recommended doses managed the pest population in chilli with minimal environmental pollution. Few insecticides were also noticeably controlled the pest population in chilli with minimal damage to natural enemies but chemicals were never the best option because of residual effects and also resurgence nature.

### Disease Management

#### Fungal

Choanephora blight is the one of the serious diseases in chilli which causes die back, wet rot, soft tissues on stem and root that can eventually lead to poor yield. (Maeda *et al.*, 2010) [42] Captan @ 0.15% was found to be effective against twig blight in chilli at field conditions. (Panja, 1999) [57] where as in green house conditions *Trichoderma* was found to be effective. (Chandrakala *et al.*, 2018) [13] Leafspot in chilli caused by *Alternaria spp.* & *Cercospora capsici* were controlled effectively when treated with Tilt 25% EC @ 0.05% + Eucalyptus spp. @ 10% + *Pseudomonas fluorescens* @ 5g/ lt. (Devappa and Thejakumar, 2016) [18] Fungicide carbendazim have controlled disease incidence of chilli anthracnose than the botanical formulations at lower doses in chilli. But in inhibiting spore germination ginger chloroform performed well *in vitro* conditions. (Choudhury *et al.*, 2017) [14] Chilli anthracnose is one among major diseases in chilli which can cause 50% crop loss. (Pakdevaraporn *et al.*, 2005) [55] Integrated disease management approach can effectively manage chilli anthracnose rather than single strategy approach. Integrated approach includes Use of disease resistant planting material, rotating with non-solanaceous crops for at least 2 years and destroying the plant debris [84]. Management of chilli anthracnose was done by soaking the chilli seeds for 12 hours in 0.2% thiram. (Chakravarthy and Anilkumar, 1975) [12] Usage of single chemical can lead to resistance rapidly. (Staub, 1991) There after few fungicides came into existence for controlling the chill anthracnose *viz.*, including 0.2% mancozeb, 0.1% ziram, Blitox 50, 0.1% Bavistin and 0.5% or 1% Bordeaux mixture as seed dressing agents. *Trichoderma spp* have effectively controlled the chilli anthracnose. (Boonratkwang *et al.*, 2007) [11] Next level of strobilurin fungicides (azoxystrobin, trifloxystrobin and pyraclostrobin) have managed the anthracnose disease in chilli. (Than *et al.*, 2008) [86]

#### Bacterial

Bacterial leaf spot caused by *Xanthomonas spp* is destructive disease in chilli which can cause total crop loss at warm and humid climatic conditions. Symptoms are developed as lesions on the leaves which are tan to brownish red in colour. Lesions may also possess yellow halo around. Group of

lesions combine to form large necrotic tissue which may eventually lead to defoliation. Spots may also occur on the infected fruits. Bacterial disease can be managed by planting disease seeds, avoiding excess irrigation to prevent the disease and not recommending the host crops like tomato and chilli within 3 years after noticing the disease in the field. (Sun *et al.*, 2002) <sup>[84]</sup>

### Viral

Chilli Leaf Curl Virus Disease (ChiLCVD) is the serious threat to chilli plants which can cause 100% yield losses at severe infection. (Senanayake *et al.*, 2007; Kumar *et al.*, 2011) <sup>[69, 39, 40]</sup> Symptoms of leaf curl virus was recorded as upward curling, limited plant growth, thickened leaf lamina and vein clearing in chilli. (Senanayake *et al.*, 2012) <sup>[70]</sup> Anyhow viral diseases are always prevented from destroying the plants by controlling the vectors of virus. Vectors of chilli leaf curl virus were controlled by chemical methods *viz.*, Diafenthiuron @ 200 ml/litre, Imidacloprid 17.8 SL (0.003%), Imidacloprid (0.05%), acephate (0.1%) and Malathion (0.05%). (Hussain *et al.*, 2017; Pandey *et al.*, 2010; Ahmed and Ram, 2016) <sup>[28, 56, 94]</sup> botanical methods *viz.*, Need seed kernel extract @5%, Seed extract of *Sapindus trifoliatus* and *Solanum trilobatum*). (Pandey *et al.*, 2010; Ahmed and Ram, 2016) <sup>[56, 94]</sup> Cultural practices like proper seed selection, discarding the infected seedlings, protecting the seedlings in nurseries, proper weed control, yellow sticky traps etc. can effectively prevent the virus in chilli. (Kenyon *et al.*, 2014)

### Conclusion

Overall summary of this paper concludes that chilli cultivation can be trouble-free and profitable when cultivated in an integrated manner. However, combined approach of management practices can give quick and affordable solutions to the biotic and abiotic threats in chilli cultivation. Abiotic threats (water related problems & nutrient related problems) can be maintained by choosing right system of irrigation and selective fertilizers. Drip irrigation can be a possible solution for efficient cultivation of chilli which can save the water consumption and prevent weeds and pests. Nutrients can be managed by combining both the organic and inorganic manures along with biofertilizers which can incline the nutrient uptake capacity and maintain good soil conditions for sustainable use. Well-maintained nutrient approach also favours the quality and quantity of the yield in chilli. Biotic threats (Insects & diseases) can be maintained by choosing the eco-friendly management practices which can fulfil two or more requirements of chilli crop. For an example, Neem cake application acted as supplement of nitrogen and also managed the thrips & mite infestation in chilli. This type of management practices can diminish the cost of inputs and improves the yield. Deep exploration is essentially required for choosing the best management practices in chilli cultivation which can reduce the cost of inputs, labour charges and improves the quality and quantity of yield.

### Acknowledgements

We thank 'Department of Science and Technology' for sponsoring to this paper under the supervision of Koneru Lakshmaiah Educational Foundation, Vaddeswaram, Guntur, India.

### References

1. Ahmed AA, Ram MR. Medicinal plant extracts for the management of leaf curl disease of chilli (*C. annum* Linn). *World J Pharm Pharm Sci* 2016;5:1916-1924.
2. Ahmed K, Hanumantha Rao V, Purnachandra Rao P. Resistance of chilli cultivars to yellow mite, *Polyphagotarsorumus latus* Banks. *Indian Journal of Agricultural Research* 2001;35:95-99.
3. Amin PW. Leaf Curl Disease of Chilli Peppers in Maharashtra, India *PANS*. 1979;25(2):131-134.
4. Anitha VB. Nitrogen management in vegetable chilli grown in pots with modified drip irrigation system (Doctoral dissertation, Department of Agronomy, College of Agriculture, Vellayani) 1997.
5. Anon. Horticultural Statistics at a Glance 2018. Horticulture Statistics Division, Department of Agriculture, Cooperation and Farmers' Welfare, Ministry of Agriculture and Farmers' Welfare, Government of India, New Delhi 2018, 458.
6. Ashwani SK, Jhorar RK, Makkar R. Response of chilli crop to different nitrogen fertigation and irrigation frequency under drip system using marginally saline water. *IJCS*, 2020;8:1557-66.
7. Aswathanarayanareddy N, Ashok Kumar CT, Gowdar SB. Effect of intercropping on population dynamics of major pests of chilli (*Capsicum annum* L.) under irrigated conditions. *Indian J. Agric. Res* 2006;40(4):294-297.
8. Avery PB, Kumar V, Skvarch EA, Mannion CM, Powell CA, Mckenzie CL *et al.* An ecological assessment of *Isaria fumosorosea* applications compared to a neonicotinoid treatment for regulating invasive ficus whitefly. *J. Fungi* 2019;5:36.
9. Baloch QB, Chachar QI, Tareen MN. Effect of foliar application of macro and micro nutrients on production of green chilies (*Capsicum annum* L.). *Journal of Agricultural Technology* 2008;4(2):174-184.
10. Berke T, Shieh SC. Chilli peppers in Asia. *Capsicum Eggplant Newsl* 2000, 38-41.
11. Boonratkwang C, Chamswang C, Intanoo W, Juntharasri V. Effect of Secondary Metabolites from *Trichoderma Harzianum* Strain Pm9 on Growth Inhibition of *Colletotrichum Gloeosporioides* and Chilli Anthracnose Control. *Proceeding of the 8th National Plant Protection Conference*. Naresuan University, Phisanulok, Thailand. 2007, 323-336.
12. Chakravarthy BP, Anil Kumar TB. Control of seed borne infection of *Colletotrichum capsici* in chillies. *Curr Res* 1975;4:172.
13. Chandrakala J, Vidyasagar B, Rajanikanth P. Efficacy of potential biocontrol agent and fungicides in management of chilli twig blight disease caused by *Choanephora cucurbitarum*. *Journal of Pharmacognosy and Phytochemistry* 2018;7(6):1875-1877.
14. Choudhury D, Saha S, Nath R, Kole RK, Saha J. Management of chilli anthracnose by botanicals fungicides caused by *Colletotrichum capsici*. *Journal of Pharmacognosy and Phytochemistry* 2017;6(4):997-1002.
15. Dale AG, Borden MA. Evaluation of reduced-risk insecticides to control chilli thrips (Thysanoptera: Thripidae) and conserve natural enemies on ornamental plants. *Florida Entomologist* 2018;101(2):237-243.

16. Deolankar KP, Firake NN. Effect of Fertigation of Solid Soluble Fertilizers on Growth and Yield of Chilli. *Journal-Maharashtra Agricultural Universities* 1999;24(3):242-243.
17. Deore GB, Limaye AS, Shinde BM, Laware SL. Effect of novel organic liquid fertilizer on growth and yield in chilli (*Capsicum annum* L.). *Asian J exp. biol. sci. Spl* 2010, 15-19.
18. Devappa V, Thejakumar MB. Integrated management of chilli leaf spot caused by *alternaria alternata* and *cercospora capsici* under field conditions. *International Journal of Advanced Research* 2016;4(4):1468-1474.
19. Devi M, Niranjana RF, Indirakumar K. Management of chilli (*Capsicum annum* L.) thrips and mites using organics. *International Journal of Current Microbiology and Applied Sciences* 2017;6(4):1541-1546.
20. EPPO. EPPO Standards - Diagnostic protocols for regulated pests - Scirtothrips aur- antii, Scirtothrips citri, Scirtothrips dorsalis. *OEPP/EPPO Bulletin* 2005;35:353-356.
21. George S. "Role of vermicompost, vermiwash and other organics in the management of thrips and mites in chilli", M.Sc. (Agri) Thesis, University of Agricultural Sciences, Dharwad, Karnataka, India 2006.
22. Ghosh BN, Singh, Raman Jeet, Mishra PK. Soil and input management options for increasing nutrient use efficiency. A. Rakshit *et al.* (Eds.) *Nutrient Use Efficiency: from Basics to Advances*, Springer 2015, 17-27.
23. Giraddi RS, Smitha MS. "Organic way of controlling yellow mite in chillies", *Spice India* 2004;17:19-21.
24. Gireesh B, Agrwal N, Tamrakar S, Sinha J. Irrigation and fertigation management for chilli (*Capsicum annum*) under drip irrigation system. *Journal of Agricultural Engineering* 2020;57(2):182-194.
25. Gundannavar KP, Giraddi RS, Kulkarni KA, Awaknavar JS. Development of integrated pest management modules for chilli pests. *Karnataka Journal of Agricultural Sciences* 2010;20(4).
26. Hiranmai Yadav R, Vijayakumari B. Influence of vermicompost with organic & inorganic manures on biometrics & yield parameters of Chilli (*Capsicum annum* L.). *Crop Research* 2003;25(2):236-243.
27. Hossain MM, Khalequzzaman KM, Mondal MTR, Alam J, Islam MS. Development of Management Approach against Thrips-Mite Complex of Chilli. *International Journal of Scientific Research in Agricultural Sciences* 2016;3(1):18-24.
28. Hussain MS, Naveed K, Atiq M. Susceptibility of chilli lines/varieties towards Chilli leaf curl virus and its management through vector control. *Pak J Phytopathol*; 2017;29:17-22.
29. Hussein MY, Samad NA. Intercropping chilli with maize or brinjal to suppress populations of *Aphis gossypii* Glov., and transmission of chilli viruses. *International journal of pest management* 1993;39(2):216-222.
30. Jain P, Singh S, Borban K, Kamde N. Bio-efficacy of novel insecticides against chilli whitefly, *Bemisia tabaci* genn, in Malwa Region of Madhya Pradesh. *Annals of Plant and Soil Research* 2018;20(2):210-213.
31. Kang S. *Plant Pathology 2.0 Mol. Plant Pathol.* 2014;15:315-8
32. Kattimani S. Response of chilli (*Capsicum annum* L.) Genotypes to integrated nutrient management. M.Sc. (Agri.) thesis, University Of Agricultural Sciences, Dharwad 2004, 128.
33. Kenyon L, Kumar S, Tsai WS, Hughes JA. Virus diseases of peppers (*Capsicum* spp.) and their control. *Adv Virus Res* 2014;90:297-354.
34. Khaitov B, Yun HJ, Lee Y, Ruziev F, Le TH, Umurzokov M *et al.* Impact of organic manure on growth, nutrient content and yield of chilli pepper under various temperature environments. *International journal of environmental research and public health* 2019;16(17):3031.
35. Khan A, Shah SNM, Rab A, Sajid M, Ali K, Ahmed A *et al.* Influence of nitrogen and potassium levels on growth and yield of chillies (*Capsicum annum* L.) *Int. J. Farm Sci* 2014;3:226-60.
36. Kotresh S, Raghuraman M, Srushtideep A. Management of chilli mites using newer formulations. *Journal of Entomology and Zoology Studies* 2020;8(4):74-77.
37. Kumar D, Raju SVS, Sharma KR. Population Dynamics of Chilli Mite and their Management with Certain Newer Insecticide Combination Formulations. *Journal of Pharmacognosy and Phytochemistry* 2019;8(2):403-407.
38. Kumar GP, Reddy BM, Das L, Anitha T, Soujanya P. Influence of integrated nutrient management on growth of chilli (*Capsicum annum* var. frutescens L.). *Technology* 2019.
39. Kumar MD, Sivamohan MVK, Niranjan V, Bassi N. Groundwater management in Andhra Pradesh: time to address real issues *Occas. Pap.* 2011, 4.
40. Kumar S, Kumar R, Kumar S, Singh AK, Singh M, Rai AB, Rai M. Incidence of leaf curl disease on capsicum germplasm under field conditions. *Indian J Agric Sci* 2011;8:187-189.
41. Kurubetta KD, Mesta RK, Tatagar MH, Abdul Kareem M. Response of Chilli (*Capsicum annum* L.) for Graded Levels of Fertilizers and Jeevamruta Application. *Journal of Pure and Applied Microbiology* 2017;11(2):1099-1103.
42. Maeda K, Karahashi Y, Ohsato S, Yoneyama K. Appearance of a new leaf rots disease on common ice plant. *Journal of General Plant Pathology* 2010;54:207-212.
43. Magdoff FH, Van E. *Building soils for better crops.* SARE, Washington, D.C., U.S.A. 2000.
44. Mahajan G, Singh KG, Rakesh Sharda, Mukesh Siag. Response of red hot pepper (*Capsicum annum* L.) to water and nitrogen under drip and check basin method of irrigation. *Asian J. Plant Sci* 2007;6(5):815-820.
45. Mahalingappa PB, Raddy KD, Raddy KN, Subbaratnam GV. Bioefficacy of certain insecticides against thrips (*Scirtothrips dorsalis* Hood) and mite (*Polyphagotarsonemus latus* Banks) infesting chillies (*Capsicum annum* L.). *Acharya N G Ranga Agricultural University* 2008;36(1):11-15.
46. Mandi N, Senapati AK. Integration of chemical botanical and microbial insecticides for control of thrips, *Scirtothrips dorsalis* Hood infesting chilli. *The Journal of Plant Protection Sciences* 2009;1(1):92-95.
47. Meena RK, Tayde AR. Field efficacy of certain bio-pesticides against chilli thrips *Scirtothrips dorsalis* (Hood) on chilli (*Capsicum annum* L.). *International Journal of Current Microbiology and Applied Sciences* 2017;6(6):2188-2192.
48. Mishra A, Dayal A. Effect of Organic and Inorganic



- Fertilizers on Seed Quality of Different Varieties of Chilli (*Capsicum annum* L.). Nat Prod Chem Res 2018;6:326. doi:10.4172/2329-6836.1000326
49. Muralikrishnasamy S, Veerabadrán V, Krishnasamy SV, Kumar S Sakthivel. Drip irrigation and fertigation in chillies (*Capsicum annum* L.). 7 th International Micro irrigation Congress. Sept 10-26, PWTC, Kuala Lumpur 2006.
  50. Nadiya N, Kurien EK, Mathew EK, Varughese A. Impact of fertigation and drip system layout in performance of chilli (*Capsicum annum*). Int. J. Eng. Res. Dev 2013;7(9):85-88.
  51. Naik DV, Singh AK, Roy H, Maja P. Assessment of Constraints Encountered by the Chilli Growers. of Khammam District in Adoption of Recommended Chilli Production Technologies along with Suggestions. Int. J. Curr. Microbiol. Appl. Sci 2019;8:2608-13.
  52. Nelson SJ, Natarajan S. Influence of barrier crops on pests of chilli under semi-dry condition. South Indian Horticulture 1994;42:390-392.
  53. Nijamudeen MS, Dharmasena PB. Performance of chilli under drip irrigation with mulch. Annual of the Sri Lanka Department of Agriculture 2002;4:89-94.
  54. Nirmal Kumar HJUS, Fasul Kabir AHM, Sultana D, Islam Z. Response of chilli to Integrated Fertilizer management in North-eastern Brown Hill soils of Bangladesh. Online J Biol. Sci 2003;3:797-801.
  55. Pakdevaraporn P, Wasee S, Taylor PWJ, Mongkolporn O. Inheritance of resistance to anthracnose caused by *Colletotrichum capsici* in *Capsicum*. Plant Breeding 2005;124:206-214.
  56. Pandey KS, Mathur AC, Srivastava M. Management of leaf curl disease of chilli (*Capsicum annum* L.). Int J Virol 2010;6:246-250.
  57. Panja BN. Relative efficacy of different fungicide *in vitro* and in field for controlling twig blight disease of chilli caused by *Choanephora cucurbitarum* (Berk and Rav.) Thaxter economically. Plant Protection Bulletin. Faridabad 1999;51(1-2):17-19.
  58. Pariari A, Khan S. Integrated nutrient management of chilli (*Capsicum annum* L.) in Gangetic alluvial plains. Journal of Crop and Weed 2013;9(2):128-130.
  59. Patil ID, Babalad HB, Patil RK. Effect of organic nutrient and biological pest management practices on insect pest and disease dynamics in organic chilli production system. Int. J. of Recent Scient. Res 2014;5(9):1524-1528.
  60. Prabhu ST, Nagaraja MV, Ganapathi T. Evaluation of bio-efficacy of Imidacloprid 17.8% SI against chilli insect pests. Indian Journals of Entomology 2015;7(20):45-48.
  61. Rao MRK, Kumar MS, Jha NK. Comparative yield analysis of chilli (*Capsicum annum* L.) by application of vermicompost and panchagavya J. Chem. Pharm. Res. 2015;7:319-23.
  62. Reddy G, Chandramohan V, Venkatachalapathi G Purna Dattha Reddy, Hebbar SS. "Study of different organic manure combination on growth and yield of chilli (*Capsicum annum* L.)." Plant Archives 2017;17(1):472-474.
  63. Reddy VA, Sreehari G. Studies on efficacy of firpronil 80 WG a new formulation and other chemicals against chilli thrips. International journal of agricultural sciences 2009;5(1):140-141.
  64. Rivitra V, Thevan K, Norhafizah MZ. Growth of chilli plant (*Capsicum annum* L.) treated with combined organic and inorganic fertilizer with *Saccharomyces cerevisiae*. In IOP Conference Series: Earth and Environmental Science IOP Publishing 2021;756(1):012050.
  65. Sanap MM, Nawale RN. Chemical control of chilli thrips, *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae). Veg. Sci 1987;14:195-9.
  66. Sani I, Ismail SI, Saad N, Abdullah S, Jalinas J, Jamian S. Insect pests of vegetables in malaysia and their management using entomopathogenic fungi. *Serangga* 2020;25(3).
  67. Seal DR, Ciomperlik M, Richards ML, Klassen W. Comparative effectiveness of chemical insecticides against the chilli thrips, *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae), on pepper and their compatibility with natural enemies. Crop Protection 2006;25(9):949-955.
  68. Selvakumar T. Performance evaluation of drip fertigation on growth, yield and water use in hybrid chilli (*Capsicum annum* L.). Ph.D. Thesis. Tamil Nadu Agric. Univ., Coimbatore 2006.
  69. Senanayake DMJB, Mandal B, Lodha S, Varma A. First report of Chilli leaf curl virus affecting chilli in India. Plant Pathol 2007;56:343.
  70. Senanayake DMJB, Varma A, Mandal BJ. Virus-vector relationships, host range, detection and sequence comparison of chilli leaf curl virus associated with an epidemic of leaf curl disease of chilli in Jodhpur. Indian Phytopathol 2012;160:146-155.
  71. Shabir A, Khan SH, Wani SH. Evaluation of Integrated Nutrient Management Practices on Yield and Economics of Chilli var. kashmir long (*Capsicum annum* L.). Chemical Science Review and Letters 2017;6(24):2195-2201.
  72. Sharu SR. Integrated nutrient management in chilli (*Capsicum annum* L.). M.Sc. (Ag.) thesis, Kerala Agricultural University, Thrissur 2000, 108.
  73. Shashidhara GB. Integrated Nutrient Management In Chilli (*Capsicum annum* L.) Under northern transitional zone of Karnataka. Ph.D. thesis, University of Agricultural Sciences, Dharwad 2000, 143.
  74. Shinde BD, Mokal AJ, Narangalkar A, Naik KV. Chemical management of whiteflies infesting chili. Int. J. Chem. Stud 2018;6:2813-2816.
  75. Shinde SS. "Effect of seaweed liquid biofertilizer (seasol) on plant growth of *Capsicum annum* L. International Journal of Researches in Biosciences, Agriculture and Technology 2020;15:125-129.
  76. Singh H, Joshi N. Management of the aphid, *Myzus persicae* (Sulzer) and the whitefly, *Bemisia tabaci* (Gennadius), using biorational on capsicum under protected cultivation in India. Egyptian Journal of Biological Pest Control 2020;30:1-9.
  77. Singh M. Socio-economic condition, problems in Chilli cultivation and suggestions obtained by Chilli growers in Abhanpur block of Raipur district. Journal of Pharmacognosy and Phytochemistry 2020;9(3):326-328.
  78. Smith HA, Stansly PA, Seal DR, Mcavoy E, Polston JE, Phyllis R, *et al.* Management of Whiteflies, Whitefly-Vectored Plant Virus, and Insecticide Resistance for Tomato Production; ENY-735; University of Florida, IFAS, Florida A&M University and Cooperative Extension Program: Gainesville, FL, USA 2018, 1-8.

79. Soreng MK, Kerketta NS. Effect of organic manures on different plant varieties of chilli (*Capsicum annum*) under subabul (*Leucaena leucocephala*) based Horti silviculture system. Journal of Medicinal Plants Studies 2017;5(5):273-276.
80. Soury MK, Sooraki FY. Benefits of organic fertilizers spray on growth quality of chili pepper seedlings under cool temperature J. Plant Nutr. 2019;42:650-6.
81. Sparkyby F. Sparky Boy Enterprises. Planet Natural, 2006, 1-6.
82. Staub T. Fungicide resistance: practical experience and antiresistance strategies and the role of integrated use. Annual Review of Phytopathology 1999;29:421-442.
83. Sujay YH, Giraddi RS, Goud KB. Role of Border and Barrier Crops for the Management of Important Chilli (*Capsicum annum* L.) Pests. Madras Agricultural Journal 2015, 102.
84. Sun X, Nielsen MC, Miller JW. Bacterial Spot of Tomato and Pepper<sup>1</sup>. Plant Pathology Circular No. 129 (Revised), Fl. Dept. Agriculture & Cons. Svcs, Division of Plant Industry, Florida 2002.
85. Tatagar MH, Awaknavar JS, Giraddi RS, Mohankumar HD, Mallapur CP, Kataraki PA. Role of border crop for the management of chilli leaf curl caused due to thrips, *Scirtothrips dorsalis* (Hood) and mites, *Polyphagotarsonemus latus* (Banks). Karnataka Journal of Agricultural Sciences 2011;24(3):294-299.
86. Than PP, Jeewon R, Hyde KD, Pongsupasamit S, Mongkolporn O, Taylor PWJ. Characterization and pathogenicity of *Colletotrichum* species associated with anthracnose on chilli (*Capsicum* spp.) in Thailand. Plant Pathology 2008;57:562-572.
87. Tumbare AD, Nikam DR. Effect of planting and fertigation on growth and yield of green chilli (*Capsicum annum* L.). Indian J. Agric. Sci., 2004;74(5):242-245.
88. Tumbare AD, Bhoite SU. Effect of solid soluble fertilizers applied through fertigation on growth and yield of chilli. Indian J Agric. Sci. 2002;72(2):109-111.
89. Varghese TS. Management of thrips, *Scirtothrips dorsalis* (hood) and mite, *Polyphagotarsonemus latus* Banks on Chilli Usig Biorationals and Imidacloprid, M.Sc. (Agri) Thesis, Univ. Agric. Sci., Dharwad, Karnataka, India 2003.
90. Veena SK, Giraddi RS, Bhemmanna M, Kandpal K. Effectiveness of plant oils for increasing the efficacy of insecticides and Acaricides against Chilli mite. J Entomol. Zool. Stud 2017;5(5):09-11.
91. Veeranna HK, Khalal A, Farooqui AA, Sujith GM. Studies on fertigation with normal and water-soluble fertilizers on fruit yield, quality and nutrient uptake of chilli. Conf. on spices and aromatic plants Calicut, Kerala 2000, 186-190.
92. Vichitbandha P, Chandrapatya A. Broad mite effects on chili shoot damage and yields. Pakistan Journal of Zoology 2011;43(4).
93. Vijayakumar G, Tamilmani D, Selvaraj PK. Maximizing water and fertilizer use efficiencies under drip irrigation in chili crop. J. Manage. Public Policy 2010;2(1):85-95.
94. Wahocho NA, Zeshan Ahmed S, Jogi Q, Talpur KH, Leghari SJ. Growth and productivity of chilli (*Capsicum annum* L.) Under various nitrogen levels. Science International 2016;28(2).