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A CRITICAL REVIEW ON AGRONOMIC MANAGEMENT OF PESTS AND DISEASES IN CHILLI

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INTRODUCTION

India is the second most populous country in the world. With the increasing population, the cultivable land resource is shrinking day to day. To meet the food, fibre, fuel, fodder and other needs of the growing population, the productivity of agricultural land and soil health needs to be improved. Green Revolution in the post independence era has shown path to developing countries for self-sufficiency in food but sustaining agricultural production against the finite natural resource base demands has shifted from the "resource degrading" chemical agriculture to a "resource protective" biological or sustainable agriculture. The vegetable crops have been well advocated in solving the problem of food security. They are rich source of minerals, vitamins, fibre and contain a fair amount of protein as well as carbohydrates. In addition to local market demand vegetables have the potential for both domestic and export market. The vegetable production of our country before independence was merely 15 million tonnes (mt) and now it is about 146.55 million tonnes during 2011-12,accounting 11.4% share of World vegetable production [25]. Although India is the second largest producer of vegetables next only to China in World, the productivity of different vegetables in our country is comparatively lower than the World's average productivity. Again the per capita availability of vegetable (210g/head/day) is still behind the recommended quantity (285g /head /day). Our demand by 2020 will be around 250 million tonnes. Thus due to the rapid growth of the population with reduction in land, in order to feed the population, the only solution is the vertical expansion or by increasing the productivity per unit area per unit time as the potential available land and water resources and of technology still remain unexploited. Sustainable Vegetable cultivation offers one of the most suitable farming systems with recurring benefits to only long-term soil health but provides a lasting stability in production by importing better resistance against various biotic and abiotic stresses.Chilli is one of the most important commercial crops of India. It is grown almost throughout the country. Chilli is raised over an area of 1832 thousand hectares in the World, with a production of 2959 thousand tons. Major chilli growing countries are – India, China, Indonesia, Korea, Pakistan, Turkey and Sri Lanka in Asia; Nigeria, Ghana, Tunisia and Egypt in Africa; Mexico, United States of America in North – Central America; Yugoslavia, Spain, Romania, Bulgaria, Italy and Hungary in Europe and Argentina and Peru in South America. India is the world leader in chilli production followed by China and Pakistan[7]. India is not only the largest producer but also the largest consumer of chilli in the world. Chillies are the most common spice cultivated in India. Chilli is a universal spice of India. It is cultivated in all the States and Union Territories of the country. India contributes about 36% to the total world production. In India, Chillies are grown in almost all the state through out the country. Andhra Pradesh is the largest producer of Chilli in India and contributes about 26% to the total area under Chilli, followed by Maharashtra (15%), Karnataka (11%), Orissa (11%), Madhya Pradesh (7%) and other states contributing nearly 22% to the total area under Chilli. [13]. Efficient plant protection enhances yield and quality in most of the crops. The present farming by and large depends on the use of chemical fertilizers, pesticides and growth regulators for enhancing crop productivity. It is a well documented fact that increased dependence on agro-chemicals including fertilizers and pesticides has led to several ill effects on soil and the environment. Maintaining good soil health is a prerequisite for sustaining higher productivity under intensive agricultural production system. Soil health is the continued capacity of soil to function as a vital living system, within ecosystem and land use boundaries to sustain the biological productivity.

Increasing awareness of environmental impact of conventional high input intensive farming system has led to a move towards alternatives. The organic (biological/ecological/sustainable) approach is one of the alternatives to conventional production system currently being advocated [34]. Considering the potential environmental benefits of sustainable production and its compatibility with integrated farming approaches, quality of food and sustainability, sustainable agriculture is considered as a viable alternative [26].

In Indian agriculture, the yield gap in various crops still remains large even after following the best management practices. Also the agricultural lands continue to shrink and there is a greater threat to global environment and soil resources in the form of erosion of biodiversity and climate change marching towards desertification and environmental pollution. Hence, there is now a great concern to maintain soil health and protect environment by popularizing eco friendly and cost effective organics. Rapid increase in population and demand of food materials has initiated the large scale use of insecticides and pesticides resulting in harmful biomagnifications and infertility of soils. Indiscriminate use of these insecticides has led to insecticide resistance, pest resurgence, killing of beneficial insects and imbalance in the ecosystem. To overcome these problems, use of biopesticides spray, plant based substances and certain indigenous practices offer safe alternatives in pest management. Today, due to awareness about the harmful effects of the chemical insecticides and technological advancement in biopesticides and botanicals production, these bioproducts are becoming popular in pest and disease management in sustainable farming.

With this background a review has been made to study the effect of integrated pest and disease management in chilli.

Effect of date of planting on the activity of thrips, mites and development of leaf curl

The time of transplanting influences the incidence of pests and diseases in chilli. Chilli crop transplanted in early June and July escapes from the incidences of thrips and mites than the crop transplanted in late July and early August in Dharwad region [15]. Lower incidence of leaf curl was observed in chilli crop, when transplanted until 15th July, while late planted crop (15th August and 30th August) was severely attacked by leaf curl [20]. Transplanting of chilli from 30th June to 15th July could escape thrips damage.[4]. Chilli crop planted in the month of June or August registered higher population of thrips, mites and resultant leaf curl on the crop whereas July 15th planting registered higher chilli yields in both unprotected and protected condition due to less pest activity and leaf curl development [10]. The maximum mite population was noticed during 42nd standard week i.e. October 15-21 on chilli cop planted during 3rd week of July.

Management of leaf curl through nutrient management

[23] opined that pests and diseases of plants were indicative of soil fertility problems. Organic fertilizers or organic systems of fertilization are less conducive to pests incidence than conventional fertilizers. Excessive use of inorganic fertilizers can cause nutrient imbalance and lower pest resistance in crops. Soils with high organic matter and active soil biology generally exhibit good soil fertility. Crops grown in such soils showed lower pest abundance due to lower nitrogen content in organically farmed crops[2]. Integrated application of neem cake @ 500 and 1000 kg ha $^{-1}$ and vermicompost @2500 kg ha $^{-1}$ in combination with 50%NPK recorded significantly lower number of thrips and mites and leaf curl index resulting in higher chilli yield[36]. Application of neem cake@ 2500kg ha $^{-1}$ + 50%NPK and sunnhemp@ 8 t ha $^{-1}$ +50%NPK recorded significantly reduced population of thrips and mites with leaf curl index of 0.43 ad 0.40 respectively[17]. [12] studied the influence of organic soil amendments and inorganics on the incidence of mite population in chilli and reported that application of neem cake @200 kg ha $^{-1}$ + 50%PK, vermicompost @2500 kg ha $^{-1}$ + 50%NPK and insitu green manuring with sunnhemp@ 5 t ha $^{-1}$ +50%NPK recorded significantly lower mite population and leaf curl index compared to 100 percent NPK alone. Combined application of full dose of NPK+FYM@5 t ha $^{-1}$ +vermicompost@5 t ha $^{-1}$ recorded lower incidence of sucking pests in chilli and application of half dose of NPK+FYM@5 t ha $^{-1}$ +vermicompost@5 t ha $^{-1}$ recorded least thrips incidence [22]. Application of organics along with inorganics drastically reduced the incidence of murda and leaf curl index on chilli. Incorporation of redgram stalk+100% recommended dose of fertilizer noticed lowest incidence of murda and leaf curl index compared to RDF alone[31]. Integrated application of 50 percent organic nutrients (OMG 1.5-Godrej product)+ 50 percent inorganic fertilizer superimposed foliar sprays with organic and chemical pesticide noticed lowered leaf curl and die back incidence in chilli[9]. Among the organic amendments used neem cake @500 kg ha $^{-1}$ with 50% RDF resulted in significantly lower thrips and mites induced leaf curl, fruit damage by *Helicoverpa armigera* and higher fruit yield[12].

Effect of organic soil amendments on chilli pests

Application of vermicompost @2.5 t ha $^{-1}$ followed by four sprays with neem seed kernel extract (NSKE) 5% and Neemazal at 2, 5, 7 and 11 weeks after transplanting alternatively and neem cake @0.5 t ha $^{-1}$ followed by with neem seed kernel extract (NSKE) 5% and Neemazal at 2, 5, 7 and 11 weeks after transplanting alternatively recorded significantly less population of thrips, mites and leaf curl index and improved growth parameters and chilli yield[11]. Application of neem cake @ 500 kg ha $^{-1}$, seedling dip with 1 per cent neem oil, followed by neem oil spray at weekly intervals reduced the thrips population to lower levels[27]. Soil application of vermicompost/FYM combination with full dose of NPK recorded minimum population of aphids and mites ad highest yield of chilli[38]. Combination of neem cake@500 and 1000 kg ha $^{-1}$ with vermicompost @2500 kg ha $^{-1}$ along with 50 percent RDN proved to be most effective in reducing thrips, mite and leaf curl index[36]. Further, [37] found that application of neem cake 500 kg ha $^{-1}$ + 50 percent RDF in combination with these sprays of RPP were superior in reducing the population of thrips, mites ad leaf curl index to the lowest level.

Role of border crop in reducing the incidence of chilli pests

Border cropping involves planting the non-attractive plant species or thick barrier crops so that it completely enriches the main crop like fortress walls. A barrier crop on all sides is useful when it is necessary to protect the crop from a pest attack that may come from several unknown directions. This technique works best against pests that tend to damage the crop along the edge of the field (atleast initially) rather than those that tend to have a random distribution throughout the crop. Border cropping functions by restricting the pest in the border area while reducing pest numbers in the centre and by preserving natural enemies. Border cropping often eliminates the use of broad-spectrum pesticides on the cash crop which helps preserve natural enemies and helps to prevent resurgence of the primary pest population, secondary pest outbreak and additional spraying to solve these 'man-made' problems. Border cropping often results in improved crop quality and dramatic pesticide savings. Less sprayings usually translates into lower costs and simplifies harvesting and marketing by eliminating re-entry (REI) and pre-harvest restrictions. Less spraying reduces the possibility of chemical residues at harvest and leads to fewer environmental and safety concerns. An ideal plant barrier should be a non-host for the virus and the vector but attractive to their natural enemies and should allow sufficient residence time to allow aphid probing before taking-off occurs[6]. At Coimbatore, [24] noticed sorghum as the best barrier crop for mosaic control in chilli. It reduced the mosaic incidence to 10.46 percent compared to control with no barrier crop (31.85%). At Tirupati,[3] observed that chilli mosaic disease caused by virus and aphids as carriers could be effectively controlled by barrier crops *viz.*, maize, sorghum and sunflower. At paramakudi, [21] observed that agathi to be the best barrier crop for both thrips and mites control in chilli. The thrips population was 4.33 leaf^{-1} ad 3.90 leaf^{-1} respectively in agathi bordered crop and chilli protected with insecticides compared to no barrier crops (11.60 leaf^{-1}). Further, they also reported maize(1.83), agathi(2.19) and sunflower(2.09) as the best barrier crops against mites. At Solan, maize and chari(*Sorghum bicolor* L.) were superior barrier crops for management of mosaic disease of chilli crop and these two crops reduced the disease incidence by 25 and 26.78 percent respectively[14]. The border crop should be taller than main crop and planted in the border could act as a barrier crops and help in reducing the pest and disease incidence and better control for non-persistently transmitted aphid borne viruses[8]. The incidence of winged aphids was reduced by 60 to 65 percent by surrounding chilli crop with maize [30]. [16] Indicated that instead of chilli growing as a monoculture if it was grow with maize show the decreased population of *Menochilus* spp.

Trap crops

The major benefit of trap cropping is that it reduces the quantum of pesticide usage on the main crop besides enhancing the natural control of pests. Usually, the trap crop will be used after every 5 rows interval depending upon nature of the crop and economics. Chilli interspersed with marigold (trap crop) in the row proportion of 20:1, 18:1 or 16:1 resulted in significantly reduced incidence of chilli fruit borer [32]. Marigold also helped in trapping the eggs and larvae of *Helicoverpa armigera*.

Banker crops

Banker crops are grown to provide the food like pollen and nectar to non-carnivorous stages of adult predator besides providing shelter and required microclimate. Many natural enemies feed directly on plant products such as pollen and nectar. Banker crops provide balanced diet for natural enemies. Insects like coccinellids require pollen for completion of their life cycle. Research findings confirmed the usefulness of banker cropping in many crop situations [17].

Effect of mixed/intercropping in pest management

Mixed/intercropping system is planting of crop in a mixed system or definite row proportions as a risk insurance measure against biotic and abiotic stresses. It is a traditional practice that has persisted over years among the farming community of the developing world. Mixed cropping or intercropping are known to reduce insect pest infestations. Natural enemies of the insect pests are enhanced by intercropping/mixed cropping through improved shelter, humid conditions and possible availability of food sources. (honey/nectar/pollen). Intercropping of chilli+tomato (1.88 and 2.25 leaf $^{-1}$), chilli+garlic (2.93 and 2.41 leaf^{-1}) and chilli+coriander (3.19 and 3.70 leaf^{-1}) were found to be best intercropping systems for reducing thrips and mites population in chilli[18]. Maize intercropping in chilli acted as a barrier crop and was effective in reducing vector movement within a plot and also preventing winged vectors from landing on chilli plants[16]. Maximum reduction in per cent chilli mosaic (70.27) and aphid population (61.81) was observed when chilli was intercropped with onion (*Allium cepa* L.) at 1: 2 row ratio [5]. Chilli intercropped with garlic/onion consistently recorded lower pest infestation levels (6.06 and 6.33) compared to chilli sole crop (13.26 and 13.53) in the two seasons respectively[29].

Effect of botanicals and indigenous materials in the management of chilli *murda* complex caused by sucking pests

In Tamilnadu, neem seed oil had proved effective to manage A.*craccivor*a and *M.persicae* that transmits chilli mosaic virus. Neem oil at both 3 per cent and 5 percent concentrations reduced the virus transmission by aphids and recorded highest mortality of aphids. Similarly, neem derivatives viz., neem oil, Comnhox Comnol Nekhex, Repelin and Orgocide proved their superiority by recording least per cent virus transmission and highest per cent aphid mortality [19]. The botanicals neem gold (3 ml l $^{-1}$), vitex 5 per cent and clerodendron 5 per cent were effective against yellow mite in chilli but were inferior to chemicals when applied only once [35]. However, after second spray they were on par with fenpyroximate (1 ml l $^{-1}$), a chemical acaricide. However, application of *Vitex nigundo* L. 5 percent (leaf extract) and NSKE 5% recorded the lowest leaf curl index due to reduction in thrips and mites incidence. Indigenous products *viz*., NSKE(2.5%)+GCK(0.5%), NSKE(5%)+ cow urine (16.66%) and GCK(1%) +cow urine (16.66%) recorded minimum leaf curl index by inflicting higher mortality of yellow mites[29].[1] reported that neem oil application @ 5ml litre^{-1} recorded 34.28 per cent reduction of chilli mite over control. Among integrated pest management strategies tried to combat insect pests of chilli, application of tobacco powder @ 100 kg ha $^{-1}$ was found to be effective in controlling thrips incidence[33]. Basal dose of neem cake powder @ 100 kg ha $^{-1}$ at the time of planting prevented termite, nematode and other soil insects.

Effect of organic soil amendments and botanicals on natural enemies

Application of neem cake @ 250 to 1000 kg ha $^{-1}$, sunnhemp@ 250 to 1000 kg ha $^{-1}$ and vermicompost @ 750 to 2500 kg ha $^{-1}$ in chilli were found quite safe to natural enemies like predatory mite, *Amblyseius* sp. and coccinellid beetle[35]. Similarly, the organic soil amendments like vermicompost(1-2 t ha $^{-1}$), neem cake(0.5 to 1.0 t ha $^{-1}$), biogas spent slurry(1.0 t ha $^{-1}$) and FYM(12.5 to 25t ha $^{-1}$) were found safer to coccinellids as well as *Chrysoperla* in chilli ecosystem[28].

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