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Effect of Pesticide in Soil Health for Production of Chickpea Crop in Beed District, Maharashtra

Mohini S Ware[1], Parasnath Bele[1], Anil Kumar[2], Manoj Kumar Ghorase[3] and SwapnaKumar[1]
[1]Department of Chemistry, Faculty of Science, Mansarovar Global University, Sehore, MP, India.
[2]Department of Biotechnology, Vivekanand Science College (VVM), Betul, MP, India.
[3]Govt. JH PG College, Betul

Abstract:
Beed district in the Indian state of Maharashtra contributes to the economic values of chickpea production on a large scale. In the field of agriculture, quality yield of gram and other crops has been obtained by the use of many types of pesticides. Chemical synthesis pesticides can contaminate soil, water, turf, soil organisms and other vegetation and its products. Pesticides by their very nature have a high degree of toxicity as they are specially formulated to kill certain organisms. India is now the second largest producer of insecticides (such as algicide, avicide, bactericide, fungicide, herbicide, insecticide, lampricide, miticide, molluscicide, nematicide, rodenticide, viricide) in Asia and twelfth in the world after China. Soil properties of pesticides added to soil can change or lose soil fertility efficiency like soil color, pH, texture, EC, OC, N, P, K, etc. Soil quality and fertility can be maintained by managing and controlling the use of pesticides.

Keywords: Agriculture, Chickpea, Fertility, Pesticide, Toxicity, Soil.

Introduction

The literature focus on the study of effect of pesticide on soil health for cultivation of chickpea crops in Beed district of Maharashtra. High quality yield of gram and other crops has been obtained by the use of many types of pesticides [1, 2]. Pesticides added to the soil can change or lose various standard parameters of soil fertility efficiency like soil color, pH, texture, EC, OC, N, P, K, etc [3, 4]. This will be controlled through managing the use of pesticides and quality and fertility will be maintained [5].

The term pesticide covers a wide range of matters that can encompass a wide range of compounds including insecticides, bactericides, fungicides, herbicides, rodenticides, molluscicides, nematicides, larvicides, plant growth regulators and soil organisms [6, 7]. Many chemical synthesis pesticides can contaminate soil, water, turf, soil organisms and other vegetation and its products. In addition to killing insects or weeds, pesticides can be toxic to many other types of organisms, including birds, fish, beneficial insects, and non- target plants [8, 9]. The popularity and widespread use of pesticides has raised serious concerns about health risks to farmers working in treated fields and through ingestion of pesticides on fruits and vegetables, and pesticide residues present in food and drinking water [10, 11]. These activities have resulted in a variety of accidental poisonings, and even routine use of pesticides can pose major health risks to farmers in the short and long term, and to the Earth's environment. Farmers in many developing countries are forced to use certain toxic chemicals as pesticides, which are completely banned in other countries, due to improperly used technology and poor maintenance or in completely inappropriate quantities the use of outdated methods and equipment for spraying, inadequate storage practices and often reusing old pesticide containers are a major risk [12]. Storage near food and water clearly pesticide exposure remains a constant threat to health, especially being seen in agricultural work environments [13]. Most insecticides have a high degree of toxicity by their very nature because they are specifically formulated to kill certain organisms. Thus some risk of harm due to the insecticide has been found. The widespread use of pesticides has raised serious concerns about the effects not only on human health but also on other wildlife and the potential hazards it poses to sensitive ecosystems [14, 15].

Humans have been using pesticides to protect their crops since 2000 BC. Elemental sulfur dusting was the first insecticide used in ancient Sumer, about 4.5 thousand years ago, in ancient Mesopotamia [16]. In the 15th century, toxic chemicals such as arsenic, mercury and lead were being used to kill insects on crops. In the 17th century, nicotine sulfate was extracted from tobacco leaves for use as an insecticide [17]. Two natural insecticides, pyrethrum, derived from chrysanthemums, and rotenone, derived from the roots of

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tropical vegetables, were discovered in the 19th century. Arsenic-based insecticides were effective until the 1950s. [16, 18, 19] The production of pesticides in India began in 1952 with the establishment of a plant near Calcutta for the production of BHC pesticide. India is now the second largest producer of pesticides in Asia after China and ranks twelfth globally. There has been a steady increase in the production of insecticides in India with increasingly advanced technical grades. India's production has increased from 5,000 metric tons in 1958 to 102,240 metric tons in 1998 [20]. The demand for pesticides in value terms in 1996-97 was about USD 0.5 billion, which is more than about 2% ofthe total world market. In general, the use of pesticides in India has been different from the rest of the world. Pesticides account for about 76% of pesticides used in India, compared to about 44% globally [21]. The main use of 45% of pesticides in India is for cotton crops, followed by cereals like paddy and wheat (Table 1).

Table 1: General Pesticides useing in Globally		
Pesticides	India (%)	World (%)
Insecticide	76	44
Herbicide	10	30
Fungicide	13	21
Others	1	5

The benefits are a result of the effect of insecticides to kill the caterpillars that eat the crop, the direct benefits of their use being higher yields and better quality of crops.

Geographical description

Beed district is a district in the state of Maharashtra, India. The area of the district is 10,693km². Beed district has a long history of many rulers and empires. In ancient times this citywas called Champavati city. The district is located at 1850'N 7545'E, is well served by road transport and train facility along with the six adjoining districts of Ahmednagar, Aurangabad, Jalna, Parbhani, Latur and Osmanabad in the state of Maharashtra. Agriculture is the main occupation in Beed, and it is largely dependent on monsoon rains. Beed is also a district that cultivates sugarcane, gram and custard apple in large numbers (Figure 1) [22].

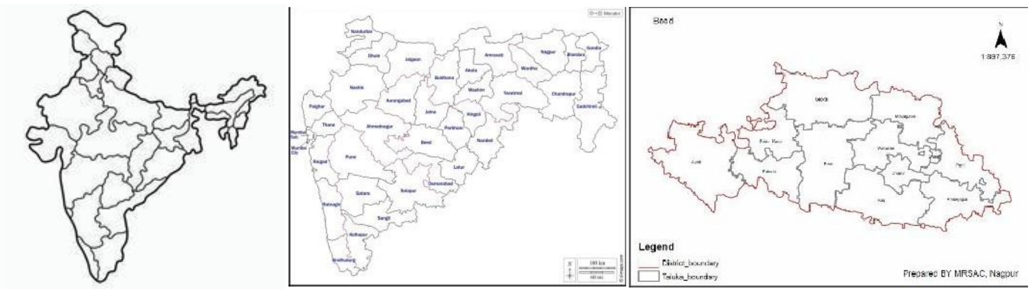

Figure 1: Location of cultivation of Chickpea crop in Beed (Maharashtra), India.

The Pesticide

A mixture of substances intended to prevent, destroy, and control any pest, including unwanted vectors of disease of human, plant, and animal. A pesticide is a chemical compound that killsor otherwise interferes with harmful organisms during production, processing, storage, transportation or marketing [23]. Food, agricultural articles, wood and wood products, animal feed ingredients, substances that can be used by animals for the control of insects, arachnids, other pests [24]. It includes substances intended for use as plant growth regulators and agents to prevent premature drop of fruits. It is used to protect items from spoilage during storage and transportation of crops [25, 26].

Some plants contain essential oils with insecticidal properties. After several decades of research on the insecticidal properties of essential oils and their constituents, few insecticides are commercially available [26]. Various NPs have inherent insecticidal properties therefore are recommended for use as nanocarriers, but are also effective as insecticidal agents or biopesticides. This approach involves the use of engineered structures of very small particles of insecticidal active ingredients with useful insecticidal properties. Acetogenin also showed insecticidal properties. Piperonyl butoxide is a compound used in a variety of insecticides to enhance the insecticidal properties of the active ingredients. Rotenone is used worldwide because it has broad spectrum insecticidal properties. A range of substances with insecticidal properties are found to be used in the treatment of internal and external parasites. In pesticide formulations, the main molecule of the pesticide is called the active ingredient, and it can enhance the insecticidal properties [27, 28].

Pesticide formulations

Pesticides are formulated in a variety of ways to improve handling, retention on foliage, safety, ease of use, and ability to mix with water [29]. There are many different formulation types. Some of them are commonly used which are described below. Emulsifying concentrates use emulsifiers to allow water-insoluble pesticides to be applied. These formulations are easily damaged in storage due to exposure to extreme temperatures. Wettable powders are pesticides formulated on dry particles that are suspended in water [30]. These formulations require constant agitation during application. Dry conductive or water dispersing granules are replacing many wet powders due to their ease of handling and reduced risk during mixing. They also remain suspended in water, but require less agitation than wettable powders [31]. Flowable formulations are used with pesticides that can only be produced in solid or semi-solid form. Soluble powders are dry formulations of insecticides that dissolve in water. Some pesticides are water soluble. They can also be prepared as a liquid. Dusts are insecticides formulated on particles designed for dry application. Granules are insecticides that are formulated on large particles of various materials. They are generally less dangerous than liquids and dusts [32, 33]. Microencapsulated pesticides are encased in tiny, slow-release plastic beads and mixed in a liquid. This formulation enhances specific efficacy [34-37]. Adjuvants are ingredients that enhance the effectiveness of an active ingredient and ease its use. The wetting agent surfactant is used to improve the spread of the spray mixture on the leaves. Surfactants are commonly used to apply insecticides to plants with waxy or hairy leaves [38, 39]. Stickers specifically improve the weathering ability of spray deposits by being washed away by rain or irrigation. Synergists enhance the activity of insecticides by blockingthe insect's ability to break down the insecticide. Penetrants enhance the absorption of herbicides into the plant. Buffers reduce the breakdown of pesticides in alkaline water [40].

Synthesis of Pesticide

Organophosphate

Organophosphates, known in organic chemistry as phosphate esters or OPEs, are a class of organophosphorus compounds with the general structure $O{=}P(OR)_3$, a central phosphate molecule with alkyl or aromatic substituents [41]. It can be considered as an ester of phosphoric acid [42]. The development of organophosphate insecticides, and their chemical structure, synthesis and reactivity are described [43]. Their toxic effects by blocking acetylcholinesterase have been described, and the symptoms of acute and chronic intoxication in humans have been outlined [44]. Organophosphate residues are a problem in the food supply. Organophosphate base pesticide is known as: Parathion, Chlorpyrifos, Diazinon, Dichlorvos, Phosmet, Fenitrothion, Tetrachlorvinphos, Azamethiphos, Azinphos-methyl, Malathion, Methyl parathion.

Synthesis of organophosphate [45-47]

$O{=}PCl_3 + 3ROH \rightarrow O{=}P(OR)_3 + 3HCl$ (Alcoholysis) $OP(OH)_3 + ROH \rightarrow OP(OH)_2(OR) + H_2O$ (Esterification)$P(OR)_3 + [O] \rightarrow OP(OR)_3$ (Oxidation)

Organochloride

An organochloride known as chlorinated hydrocarbon is an organic compound containing by the side of slightest one covalently bonded atom of chlorine. The structural (R-Cl) diversity and assorted chemical properties of organochlorides provide ascend to a wide range of names, applications and properties. Organochlorine compounds are of extreme environmental concern, with TCDD being one of the for the most part infamous [48]. Organochloride base pesticide is known as: DDT, aldrin, dieldrin, endrin, heptachlor, chlordane, endosulfan, dicofol, mirex,kepone, and pentachlorophenol.

Synthesis of Organochloride [48]

$H_2C{=}CH_2 + HCl \rightarrow CH_3CH_2Cl$ (chloroethane)

$CH_2{=}CH_2 + 2HCl + 1/2O_2 \rightarrow ClCH_2CH_2Cl + H_2O$ (oxychlorination) $ROH + SOCl_2 \rightarrow RCl + SO_2 + HCl$ (sulfuryl chloride)

$3ROH + PCl_3 \rightarrow 3RCl + H_3PO_3$ (phosphorus trichloride)

$ROH + PCl_5 \rightarrow RCl + POCl_3 + HCl$ (phosphorus pentachloride)

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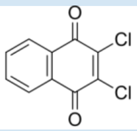
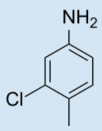
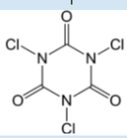
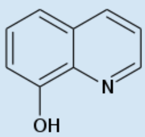
Pyrethroid
Pyrethroid is an organic compound similar to natural pyrethrin, produced by the flowers of Pyrethrum. Pyrethroids are used as commercial and household insecticides. Pyrethroids are toxic to insects such as bees, dragonflies, mayflies, gadflies and some other invertebrates, which constitute the basis of aquatic and terrestrial food webs [49, 50]. Pyrethroid base pesticide and organic compounds are known as: Allethrin, Bifenthrin, Cyfluthrin, Cypermethrin, Cyphenothrin, Deltamethrin, Dimefluthrin, Etofenprox, Flumethrin, Metofluthrin, Permethrin, Phenothrin, Resmethrin, Silafluofen, Tefluthrin, Tetramethrin, Transfluthrin. Pyrethroids are usually dissociated by sunlight and the atmosphere within a day or two, although they may persist for some time when attached to sediment. Pyrethroids are very toxic to cats, but generally not toxic to mammals, birds and dogs [51]. These are often toxic to fish, reptiles and amphibians.
Sulfonylureas
Sulfonylureas are a class of organic compounds used in agriculture. The functional group consists of a sulfonyl group (R–S (=O) 2), whose sulfur atom is bonded to the nitrogen atom of the urethane group. The side chains R1 and R2 distinguish the various sulfonylureas. Sulfonylureas inhibit the plant enzyme, acetolactate synthase, resulting in branch chain amino acid synthesis, and are generally more potent herbicides [52, 53]. Sulfonylureas base pesticides are known as: Chlorsulfuron, Flazasulfuron, Metsulfuron-methyl, Sulfometuron- methyl, Tribenuron-methyl.
Types of Pesticide: The properties of pesticide and targeted groups (Table 2), find the description of pesticides (Table 3).

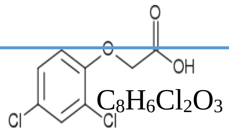
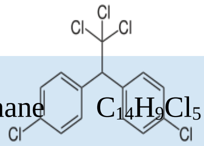
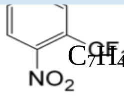
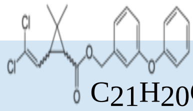
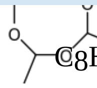
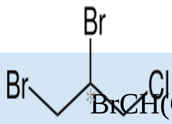
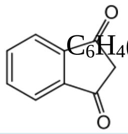
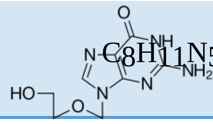
Table 2: Types of pesticides and their use again pests

Name of Pesticides	Targetgroup	Properties	References
lgicides or algaecides	Algae	Algaecide or algicide is an biocide used to kill and inhibit the growth of algae, including cyanobacteria.	[54,55]
Avicides	Birds	An avicide is usually a chemical used to kill birds.	[56]
Bactericides	Bacteria	A bactericide or bacteriocide is a substance abbreviated as Bcidal that kills bacteria. Bactericides are disinfectants, antiseptics and antibiotics.	[57,58]
Fungicides	Fungi and oomycetes	Fungicides are organic chemical compounds used to kill parasitic fungi and their spores. A fungicide inhibits their growth. Fungi cause serious damage in agriculture, which can result in loss of yield, quality and profit.	[59, 60]
Herbicides	Plant	Herbicides, commonly known as weed killers, are substances that are used to control unwanted plantweeds.	[61,62]
Insecticides	Insects	Pesticides are substances that are used to kill insects. These also include ovicides and larvicides used against insect eggs and larvae, respectively. These	[63-65]

		insecticides are used in agriculture, medicine,industry.	
Lampricides	Lampreys	Lampricide is also a chemical compound designed to target the larvae of river lampreys before they develop into parasitic adults. Lampricide is used in the upper waters of lakes to control Petromyzon marinus, an invasive species of lakes.	[66]
Iiticides or acaricides	Mites	Acaricides are insecticidal chemicals that kill members of the arachnid subclass Acari, which includes ticks and mites. Acaricides are used both in medicine and in agriculture.	[67]
scicides	Snails	Molluscicide, also known as snail baits, pellets, are insecticides against molluscs, commonly used in agriculture especially to control slugs and snails that damage crops.	[68]
Nematicides	atodes	Nematicide is a chemical insecticide used to kill plant-parasitic nematodes. Nematicides are toxic which have the properties of migration through the soil.	[69]
Rodenticides	Rodents	Rodenticides are chemicals made for the purpose of killing rodents. Referred to as rat poison, rodenticides are used to kill rats, squirrels, woodchucks, chipmunks, porcupines, nutria, beavers, and voles.	[70, 71]
Virucides	Viruses	A physical or chemical agent that inactivates or destroys a virus. It is virucidal, a specified biocidal agent known as biocides.	[72,73]

Table 3: Some specific pesticide and their description

Name of pesticides	ommonName	Chemical Name	Structure	Formula	MW
Algaecides	Quintar	Dichlone		$C_{10}H_4Cl_2O_2$	227
Avicides	Starlicide	3-Chloro-4-methylaniline		C_7H_8ClN	141
Bactericides	TCCA	roisocyanuricacid		$C_3Cl_3N_3O_3$	232
Fungicides	Oxine	8-Hydroxyquinoline		C_9H_7NO	145

Herbicides	2,4-D	rophenoxyaceticacid		$C_8H_6Cl_2O_3$	221
Insecticides	DDT	ichlorodiphenyl-trichloroethane		$C_{14}H_9Cl_5$	354
Lampricides	TFM	3-trifluoromethyl -4-nitrophenol		$C_7H_4F_3NO_3$	207
Miticides	Permethrin	Permethrin		$C_{21}H_{20}Cl_2O_3$	391
Molluscicides	Metal salt	Metal salt		$C_8H_{16}O_4$	176
Nematicides	DBCP	1,2-Dibromo -3-chloropropane		$BrCH(CH_2Br)(CH_2Cl)$	236
Rodenticides	Indandione	1,3-Indandione		$C_6H_4(CO)_2CH_2$	146
Virucides	ACV	Aciclovir		$C_8H_{11}N_5O_3$	225

Soil

Soil, commonly known as the upper part of the earth is made up of a mixture of organic matter, minerals, gases, liquids and organisms, which mainly provide nutrients for plant growth and soilorganisms [74, 75].

Solid soil

A functional property of the solid phase of soil is the solid phase includes: rock and mineral fragments, secondary minerals and organic matter. These materials are derived from the biosynthesis and decomposition of plant and animal tissue, through weathering, and through the deposition of parent material, mineral and organic particles from the air. In soil minerals, both Si^{4+} and Al^{3+} occur as small, highly charged cations, which coordinate with O ions (O^{2-}) to formthe silica tetrahedron and aluminum octahedron. In both of these structures, the small central ion is surrounded by four or six O_2- or OH-. On an amount basis, larger ions predominate in clay- forming minerals and also in clay minerals [74, 76, 77].

Soil pore space

The volume of soil which is not occupied by the soil particles is known as pore space. Thesepore spaces are usually filled with air and water. The air-filled pores form the gaseous phase of the soil system. Oxygen is essential for all biological reactions taking place in the soil [74,78].

Types of Soil

The soil types are classified into the following four points which are: sandy soil, silty soil, clay soil and loamy soil [74].

Soil profile

During its formation the soil settles in layers. These layers are known as soil profile. It is the vertical section of soil that is visible from the soil pit. Soil layers can be easily identified based on the color of the soil and the size of the soil particles. These are classified into three major zones: top soil, sub soil and parent rock [74, 79].

Soil horizon

From the open surface to the inner core, the structure of the earth's crust is divided into different zones in which some important zones are known as 'O', 'A', 'E', 'B', 'C' and 'R' horizons [74].

Soil moisture

The soil contains moisture according to its structure which absorbs water in different forms and is known as different categories of moisture: Gravitation water, Hygroscope water, Chemically combined water, Capillary water, and Atmospheric humidity [74].

Measuring soil moisture

Soil moisture can be measured with various useful instruments known as: Tensiometer, Electrical resistance blacks, Time domin reflectometry (TDR) [80].

Health of Soil

Soil health can be assessed mainly by three parameters which are available in the balance of physical, chemical and biological properties of the soil. Various factors can affect soil properties including pesticides [74, 77].

pH of Soil

Electrometric method is commonly used for the determination of soil pH. In this method, the concentration of H+ ions present in the soil solution is measured with the help of glass, hydrogen or quin-hydrogen electrodes. The pH value between in range from 6.0 to 8.0 is best for soil fertility. pH meter for soil normal are 6.5-7.5, saline <8.5, saline sodic >8.5, sodic
>8.5. The determination of pH is affected by many factors. Pure distilled water has an equal concentration of H+ and OH- ions (10^{-7}m mol per liter) which makes it neutral in the reaction [74, 76].

H_2O or HOH = $H^+ + OH^-$

Electrical Conductivity of Soil

The electrometric method is used to determine the electrical conductivity of the soil. With the help of salt bridge, the concentration of soluble salts present in the soil is measured. Salt bridge works on the principle of Wheatstone bridge. They are of two types, analog and digital. Electrical conductivity is calculate as ratio 1:2 soil - water solution find the values indSm^{-1} <0.8 Normal 0.8-1.6 Important for sensitive crops 1.6-2.5 Important for tolerant crops
>2.5 Harmful for all crops [74, 75].

Soil Organic Carbon

The amount of nitrogen available in the soil is closely related to the amount of organic carbon present in the soil. The organic carbon determining the amount of available nitrogen in the soil can be calculated. All the organisms and their remains present in the soil through various sources known as organic matter added to the soil. In normal soil it ranges from 01.-0.5%, whilein organic soil it ranges from 20-90%. Soil organic matter helps in increasing the water and nutrient holding capacity and air movement in the soil. It also improves soil structure and pore size distribution as well as total soil porosity. Organic matter is the main source of nitrogen in the soil. It also supplies 5-60% phosphorus and 80% sulfur to the plant [74, 78].

Nitrogen in Soil

Nitrogen is present in the soil in organic form such as proteins, amino acids, amino sugarsetc. In soil it is also present in inorganic form like ammonium, nitrate and nitrite. Plantsobtain nitrogen from the soil in the form of ammonium and nitrate. Alkaline permanganate is used to oxidize the organic matter available in the soil, it reacts with water to form ammonium compound. Available nitrogen (kg/ha) can be interpreted as: low at 150-250, medium at 250- 400, high at 400-600 [74, 79].

Phosphorous in Soil

Phosphorus is one of the essential nutrients for plant growth, along with nitrogen and potassium. It is found in soil in both inorganic and organic forms. The inorganic form is an important one with respect to the availability of phosphorus. Plants absorb phosphorus from the soil in ionic form. It is available in various ionic forms ($H_2PO_4^-$, HPO_4^2) in soil solution. It accounts for 0.5% of the total phosphorus in soil and its availability in soil is very low and is about 5 to 100 kg/ha [74, 77].

Potassium in Soil

Potassium is found in soil in four forms which are water soluble, exchangeable, non- exchangeable and lattice-K. The first two of these are readily available to plants, which is 1.0% of the total potassium present in the soil. The amount of exchangeable potassium is much greater than that of water-soluble potassium. But both these forms are in balance with each other. When both of these forms are depleted, a portion of the non-exchangeable potassium is converted to exchangeable and water-soluble potassium [74, 75].

Chickpea

Chickpea or *Cicer arietinum* is an annual legume of the Fabaceae family. Its different types are known as gram, Bengal gram, chhena, chana, garbanzo bean, Egyptian pea.

Chickpeas then spread to the Mediterranean region around 6000 BC and to India around 3000 BC. It is also important in Indian cuisine, used in salads, soups and stews and curries, in chana masala, and in other food products that contain chickpeas. In 2019, India was responsible for 70% of global chickpea production. In 2020, world production of chickpeas was 15 million tonnes, led by India accounting for 73% of the global total, and Turkey, Myanmar and Pakistan as secondary producers [81, 82].

Crop of Chickpea

The plant is 20-50 cm tall and has small, feathery leaves on either side of the stem. Chana is a type of pulse, which has two or three grains in one grain. It has white flowers with blue, purple or pink veins. Dozens of varieties of chickpea are cultivated around the world. In general, American and Iranian chickpeas are sweeter than Indian chickpeas. Kermanshah chickpeas in sizes 8 and 9 are considered among the highest quality in the world.

Food properties of chickpea

Chickpea is a nutrient-dense food, providing a rich content of 20% or more of the Daily Value (DV) per 100 grams of protein, dietary fiber, folate and reference amounts of some dietary minerals such as iron and phosphorus. Thiamin, vitamin B6, magnesium and zinc are moderate in content, providing 10-16% of the DV. The protein in cooked and sprouted chickpeas is richin essential amino acids such as lysine, isoleucine, tryptophan and total aromatic amino acids, which exceed the reference levels established by the Food and Agriculture Organization of the United Nations and the World Health Organization. In some parts of the world, including India, young chickpea leaves are cooked and eaten as a green vegetable [83,84].

Ancient peoples also associated chickpeas with Venus because they were said to offer medicinaluses such as increasing semen and milk production, inducing menstruation and urination, and helping to treat kidney stones. The White Caesar was considered particularly strong and helpful. Chickpea consumption is under preliminary research for its potential to improve nutrition and affect chronic diseases [85].

Pathogens of chickpea

The number of pathogens worldwide increased from 49 to 172, of which 35 were recorded in India. These pathogens originate from groups of bacteria, fungi, viruses, mycoplasmas and nematodes and show a high genotypic variation. The most widely distributed pathogens are Ascochyta rabiesi (35 countries), Fusarium oxysporum f.sp. ciceris (32 countries), Uromyces ciceris-aritini (25 countries), bean leafroll virus (23 countries), and Macrophomina phaseolina (21 countries) (Figure 2). Wet weather favors the emergence of Ascochyta; Spores are carried bywind and splash of water to young plants [15, 85-86].

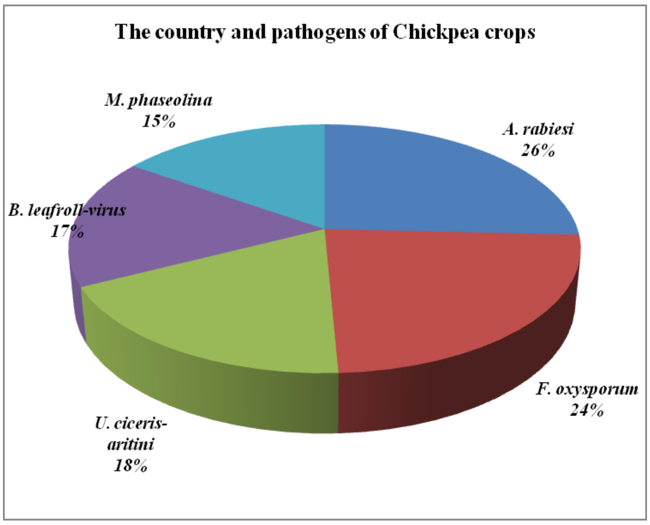


Figure 2: The country % infected with specific pathogens of Chickpea crops

Conclusion

The information collected is shared through the farmer for management and use of pesticides in agriculture. Pesticides can be direct synthesis by chemical reaction and some can be obtained by isolation from natural resources. Pesticides made from natural sources no longer have any harmful effects on the soil environment. Soil quality plays the most important role in high production of specific chickpea crop. The economic importance of gram crop is very high as it is a plant rich in nutrients.

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