Introduction

Agriculture is the backbone of Indian economy. The history of agriculture in India dates back to the Rigveda. Today, India ranks second among the world in farm output. Agriculture and its related sectors like forestry and fisheries accounts for 13.7% of the GDP (Gross Domestic Product), The economic input of agriculture to India's GDP is gradually decreasing with the country's broad-based economic growth. Still, agriculture is demographically the huge economic sector and plays an important role in the overall socio-economic fabric of India (Anonymous, 2013).

Agriculture is the primary employment of 70% Indian population for their livelihood and constitutes a major source of income for farmers who live in villages, it fulfill the basic need of human beings and animals. It is an essential source of raw material for many agro-based industries. India’s geographical condition is unique for agriculture because it provides various favorable climatic conditions.

Food famine is one of the most solemn global troubles in this country and hence to meet the expanding food demands of hastily growing world population crop production need to be increased (Ahmadi et al., 2007). Agriculture is facing the challenge of feeding ever increasing global population while the natural resources are declining due to several factors. In order to feed the increasing human population, there is a need to obtain high yield. So for this purpose, one of the methods which are used against pest and diseases is the usage of pesticides. However, the environmental pollution has reached elevated levels due to pesticides usage and other chemicals, in turn, it affects living organism (Kaymak, 2005)

Extreme uses of herbicides evidently influence all aspects of the primary and secondary metabolism of the crops associated with growth and development. India account for about 2.4% of the world’s geological area and 4% of water, but has to sustain about 17% of the world’s population and 15% of the livestock (Anonymous 2012-13).

One of the regular and foremost problems faced by the farmers all through the globe is of weeds. Weeds are unsightly, undesirable and troublesome plants, which tend to cause damage to the main crops by harboring pests and in turn lowering the yield. Weeds comprise a serious and continuing limitation to crop production in all
agricultural systems. They fight for space, and sun light with main crop plants, it also uses available soil fertility and moisture and hence it reduces the crop quality and yield (ICARDA, 1986). The problems due to weeds are more evident in the era of modern agriculture mainly due to use of high amount of fertilizers, it promotes the growth of weeds along with main crop (NRCWS, 2007).

Weeds are the plants that grow where they are unwanted. Common weeds are fast growing, resilient nuisances that compete with cultivated plants for nutrients, water, and sunlight. They serve as hosts for several pests and diseases. Removal of weeds is time consuming and it can be costly. The key to flourishing weed control is to prevent them from becoming well established. Weed species are either grassy type or broadleaf. Some examples of broadleaf weeds are clover, dandelion. Some examples of grassy type weeds are nuts edge, pampas grass, and bermuda grass. Weeds can be further classified into annuals, biennials, and perennials. Other than agricultural field, growth of weeds also affects the aesthetic look of the ecosystem. Weeds are easily acclimatized to different kinds of environmental conditions. It can never be completely removes because weeds are also a part of ecosystem, so we can allow growing where they do not cause economic loss.

Most of the weeds hamper with food production in agriculture. In order to prevent loss of crop yield they must be controlled. They also are growing along with the decorative goals like lawns, agricultural landscape, golf field and playing fields. Approximately 200 species of weeds are distributed throughout the world. Of these, nearly about 80 species interfere with crops. Most of the weeds belong to three families’ viz. Cyperaceae, Atraceae and Poaceae (Steribing, 1988).

The other issue faced in the agricultural field is invasive alien weeds. Invasive alien weeds pose a severe hazard to the biodiversity of natural ecosystems and a significant constraint to crop production. Invasive alien weeds are characterized by the maximum threat to the preservation of world biodiversity after habitat devastation, as well as imposing an increasing financial burden on agriculture (Kaiser 1999; Mack et al. 2000; Mooney 2001).

Weeds are major bottleneck for the destruction of global biodiversity by changing habitat structure via a number of diverse processes. For example, direct fight
with the native flora may result in monocultures of an alien weed, such as by *Psidium cattleianum* in Mauritius. Along with that, direct competition can be aided by allelopathic effect by the weed, such as *Parthenium hysterophorus* L. in Australia and India (Evans 1997). Plant species are widely moved all around the world through humans, as a result of trading actions. This leads to exotic species forming a major part of the agricultural weed flora, and in natural ecosystems, invasive weeds are virtually exclusively alien (Groves et al. 2001).

Weeds can also cause more dangerous effects, like the alteration of the hydrology of a region, resulting in fundamental change in the type of habitation that can be supported, for example the effects of *Andropogon virginicus* L. on tropical rainforest in Hawaii (Cronk and Fuller 1995). In barren lands weeds grow very luxuriantly, affect the aesthetic look of ecosystem as well as the native biodiversity. The problems of weeds are likely to increase due to the increased emphasis on high agricultural inputs. Globalization also results in new weed problem now withstanding strict quarantine regulation; all the agricultural crops are affected /disturbed by different types of weeds (ICARDA, 1986).

Agricultural practices develop along the way in which agro chemicals played very important role in all the different stages of plant development. In the development of agricultural processes, pesticides have become an essential tool as a plant protection agent for boosting food production (Abhilash and Sing, 2009). Agrochemical, is an abbreviation of agricultural chemical, is a generic term for the array of chemicals used in agriculture.

In most cases, agrochemical refers to the wide range of pesticides, including insecticides, herbicides, fungicides and nematicides. It may also include hormones, synthetic fertilizers and supplementary chemical growth agents (https://en.wikipedia.org/wiki/Agrochemical) (Anonymous 2014). An important factor in agriculture over the last decades is the use of pesticides to protect the crop from insect and pest while it is injurious to quality and yield of crops

The injudicious application of agrochemicals forms an essential part of the crop production technology that makes it possible for the farmers to feed the ever growing population. The use of pesticide at high dose may cause toxicity problem,
which can deleteriously affect the plant growth and development, due to reduction in the photosynthetic activity which in turn delay the time of fruit harvest and affect the crop quality and yield (Xia et al., 2006).

The pesticide residue and metabolites can accumulate in the plants and soils. Higher concentration of certain pesticide metabolites particularly herbicides are found to be phytotoxic. Approximately 98% of foliar sprayed insecticides and 95% of herbicides accumulate other than their target plants. In addition, pesticides reduce the nitrogen fixation and destroy the threatened and endangered species. The Global scenario of pesticides consumption (Fig. 1) includes insecticides (65%), herbicides (17%), fungicides (10%) and others (33%) (Fishel, 2013). Indian scenario of pesticide consumption insecticides (65%), herbicides (40%), fungicides (10%) and others (33%) (Fig: 2).

![Fig. 1: Global scenario of pesticides usage](image)

Evaluation of Alachlor (Lasso) effect on early seedling, growth and yield of Maize
During the green revolution, huge chemical fertilizers and pesticides were used to increase the production of food crops needed to the needs of the ever growing human population (Tilman et al., 2002). The worldwide food scarcity is a severe comprehensive problem and hence to meet the intensifying demands of hastily growing world population for food to be augmented (Verma et al., 2013). To boost the agricultural productivity herbicides are being used, which is an important member of pesticide family. The herbicide usage is rising at a very high rate in modern agricultural practices (Kundu et al., 2006).

One of the possible way to enhance the agricultural productivity with the effective pest management is by using pesticides. Because ~45% of annual food production is lost due to pest infestation, to sustain the agricultural practices, herbicides are being used, which is an important member of pesticide family. The imbalanced and extensive use of pesticide negatively influenced the soil-plant-environment system. Such chemicals create various environmental problem via biomagnifications (Verma et al., 2014). Generally agricultural fields are invaded by different kinds of pest and diseases leading to serious problem. In order to overcome from these problems various pesticides are being used. Thereby pesticides form an integral part in the crop fabrication. About 900 chemical compounds are used as pesticides (Durham, 1974). The pesticides are a various group of organic and inorganic chemicals like insecticides, herbicides, nematicides, fungicides and soil...
fumigants. In agriculture, these pesticides are applied to field to progress the crop yield and quality and to maximize the economic returns by avoidance of pest infestation. The pesticides are bioactive, toxic substance and it promotes directly or indirectly, soil fertility, health, as well as agro ecosystem quality (Joergensen and Emmerling, 2006; Lo, 2010)

The weed control strategies include hand weeding, crop rotation, mechanical practices and herbicide treatment. Application of weed control is an integral part of the method for plant protection. Herbicides are known to be used only for Weed destruction and the remaining amount accumulates in the environment (Kozhuro et al., 2005). The use of herbicides to control the weed is not new to agricultural farming (Zanda et al., 2007). Inter cropping cereals with legumes is an effective approach for boosting the crop production and quality of cereal crop. Modern agricultural practices are directed to increase the food production per unit area and time through intensive cropping system by using highly resistant varieties, hybrid varieties, crop rotation and chemical use (Rao et al., 1980).

Globally herbicide comprises 50 % of total pesticide sale and in some countries like Australia, USA and Germany the amount of pesticide is as high as 60 - 70%. In India, the position is different as herbicide forms less than 15% of total pesticide consumption. The rate of consumption increased rapidly from 4100 in 1988-99 to 11000 metric tons in 2001 -02 and it is likely to increase in future. Currently about 85% of herbicide is used for crops, such as wheat (57%), rice (17%), plantation crops (6%) and soyabean (4%) (Bhat and Chopra, 2006).

Herbicides are selective, cost effective, easy to apply and if applied in proper dose they become ecofriendly (NRCWS, 2007). The dose, method, time and frequency and mode of application and types of herbicides have positive effect. The continuous use of these herbicides leads to alarming threat to human beings and creates environmental pollution. Hence ecofriendly management system can be adopted for to control the weeds (Mandal, 1997).

Herbicides may be classified based on one or more common characteristics such as chemical composition or mode of action or time of application. Selection of herbicides depends upon the various factors like stage of planting, weed growth and
Introduction

crop plant. Based on chemical composition, it can be classified in to organic and inorganic, based on mode of action they are classified in to contact and systemic herbicides, based on time of application as soil applied, pre and post emergence, based on manner of absorption as soil herbicide (Soil herbicide-Root absorption systemic) and foliage herbicide (contact) and based on range of application as selective and non selective. Systemic herbicides are translocated through the plants either from shoots to roots or from root to shoots. Pre emergence herbicides are applied to the soil before the crop emergence it prevents early growth of weed seeds whereas the post emergence herbicides are applied after the crop has emerged (Kuhns et al., 1998).

Herbicides are considered as metabolic inhibitors and their mode of action may be classified in to different groups; Photosynthetic inhibitor, Cell growth disrupter, Growth regulators, Carotenoid biosynthesis inhibitor, Lipid biosynthesis inhibitor and Branch chain amino acid inhibitor (Hess, 1999). Herbicide can be classified based on selectivity; as Broad leaf control, Grass control, Persistence, Pre emergence or Post emergence (Peterson et al., 2001).

The herbicide Alachlor (2-chloro-N-(2, 6 diethylphenyl)-N-(methoxymethyl) acetamide), is widely used as selective herbicide to control the broadleaf weeds and annual grasses in the field of brassica, soybean, sugarcane, maize, and cotton. The herbicide Alachlor belongs to chloroacetanilide group of herbicides developed by Monsanto Company in 1985. In India this herbicide is available as Lasso. It is used both as pre and post emergence. The herbicide is available as emulsifiable concentration (Kiely et al., 2004 and Hackett et al., 2005). The herbicide alachlor is absorbed by emerging plant shoots, inhibits fatty acid and lipid biosynthesis; as well as gibberellins and protein synthesis (Chang et al., 1985).

Oils and fats are rich source of energy and an important component of human diet. The important oil seed crops grown in our country are sunflower, soybean, groundnut, castor, linseed and sesame. Pulses are the most important food crops for man throughout the world Pulses belong to the family Leguminosae, among Pulses used by the man species of Phaseolus, Glycine, Vigna, Arachis, Vicia and Cajanas are considered to be important (Ruskin, 1979). Soybean is cultivated as an intercrop as well as rotational crop with crops like wheat, corn, sorghum and oat. The potassium
and phosphorus requirement of soybean are fulfilled by fertilizer application usually applied to the cereals and nitrogen availability of cereals are needed by legume residues (Chanabasappa and Nanjappa, 1992).

Soybean plays a vital role in boosting oilseed fabrication in the country. It stands second, amongst the nine oilseed crops, followed by groundnut in production in the country. It has wonderful nutritive value with 20% oil and 43% protein, is also rich in vitamins, mineral, iron, salts and aminoacids (Sangeetha et al., 2013). Soybean (Glycine max L. Merrill) is one of the most abundant sources of oil and proteins. It is also called Poor man’s meat. Besides it contains high levels of amino acids lysine, lucine, lecithin and large amount of phosphorus. Soybean is a two dimensional crop as it having about 40-42 % of high quality protein and 20-22 % of oil fairly high unsaturated fatty acids. It is now well established as the cheap source of protein and edible oil (Pradhan et al., 2010) and now a day’s its gaining more importance due to increasing demand for various soy products (Bosle et al., 2005).

Fat-free soybean meal is a major and cheap source of protein for animal feeds and other packaged meals; soy vegetable oil is an added product of processing the soybean crop. For example, soybean products such as textured vegetable protein are ingredients in many meat and dairy analogues (Riaz and Mian, 2006). Soybeans produce significantly high protein per acre than most other uses of land (Anonymous, 2012). The main producers of soybean are the United States (36%), Brazil (36%), Argentina (18%), China (5%) and India (4%) (Fig. 3) (Anonymous, 2012, 2013). In India major soybean growing states are Madyapradesh (44%), Maharashtra (27.8%), Rajasthan (9.29 %), Karnataka (1.75 %), Andrapradesh (1.56 %), Chhattisgarh (0.72%) and Gujarat (0.74%) (Fig. 4). The soybeans have significant amounts of phytic acid, alpha-linolenic acid, and isoflavones. Soybeans contain a maximum amount of phytic acid, which is acting as an antioxidant and a chelating agent.

Soybeans are an excellent source of essential nutrients, providing in a 100 gram serving, high contents of the Daily Value (DV) particularly protein (36%), dietary fiber (37%), iron (121%), manganese (120%), phosphorus (101%) and several B vitamins, including folate (94%). High contents also exist for vitamin K, magnesium, zinc and potassium. The chief soluble carbohydrates of soybeans are the sucrose (2.5–8.2%), the trisaccharide raffinose (0.1–1.0%) composed of one sucrose
molecule connected to one molecule of galactose, and the tetrasaccharide stachyose (1.4 to 4.1%) composed of one sucrose connected to two molecules of galactose (Ralph et al., 2011).

Fig. 3: Top 10 soybean producing countries

Fig. 4: Major soybean growing states in India
Consumption of soybean and its products may also reduce the risk of colon cancer, possibly due the presence of spingolipids. Soybean crop nourishes the soil by fixing the atmospheric nitrogen and the addition of organic matter in the form of leaves at maturity. Soybean is cultivated with wheat, corn, oat and sorghum as an intercrop as well as rotational crop. It is also one of the main oil seed crop in the world accounting for 50% of oil seed production and 80% of total supply of all vegetable oil (Anonymous, 2005).

Soybean is grown during kharif and rainy seasons in India. The preliminary growth of this plant is slow and it showed modest lateral spread, the available interrow space promotes weed growth posing severe weed competition. Due to weed competition with main crop the yield reduces significantly, depending upon the weed flora, period, density and other factors. The serious weed obstruction in soybean is between fourth and sixth week after seedling emergence. Maintaining weed free circumstance up to 30 to 45 days in the field is necessary for getting higher yield (Patil et al., 1999). The yield losses due to weeds may vary from 20 to 70% (Kurumawanshi et al., 1995). The major weed species observed in the soybean fields Digitaria marginata, Parthenium hysterophorus, Argemone mexicana, Solanum nigrum, Euphorbia hirta, Chenopodium album, Acalypha indica, Phyllanthus niruri, Celosia argentea (Tiwari and Kurchania, 1990).

Among the plants used by the man for their food, members of the family gramineae occupy top most position followed by Pulses. Cereals are generally grown for their starchy seeds. Off all the cereals Oryza sativa, Triticum aestivum, Zea mays and Sorghum vulgare have received more importance and superior position in the world scenario of agricultural production (Ruskin, 1979).

Maize (Zea mays L.) is one of the most multipurpose emerging crop having a range of adaptability under diversified agroclimatic conditions. Maize is considered as queen of cereals because it has maximum genetic yield potential. It is grown on nearly 150 m ha in about 160 countries having diversity of soil, climate, biodiversity and management practices and that contributes 36% in the global grain production. The United States of America is the top producer of maize, contributes nearly 35% of the total grain production in the world. The USA has the maximum productivity (>

Introduction
Introduction

Maize is one of the important cereal in the world’s agriculture economy both as food for human being and feed for animals. It is also used as livestock feed, poultry feed and also producing raw material for a number of industries. Among the cereal crop it occupies third position in the world after wheat and rice with a yield of 590 million tonnes and efficiency of 4229 kg per ha which occupies an area of 139 million ha. (Anonymous, 2007).

Among the cereals grown in India, maize is gaining significant importance on account of its growing demand for diversified uses, especially as animal feed and corn based industrial raw material. Maize crop has multiple uses. The kernel contains about 77 per cent starch, 2 per cent sugar, 9 per cent protein, 2 per cent ash on water free basis. Maize oil has higher poly unsaturated fatty acid content and low in linoleic acid (0.7%) and contains high level of natural flavor. Maize is used primarily as a food for humans in most parts of the world, in contrast to the United States where about 85 per cent of the crop is used as cattle feed (Anonymous, 2009).

Maize is cultivated in all states of the country throughout the year for different purposes including grain, green cobs, sweet corn, fodder, pop corn, baby corn, in peri-urban areas. The top maize growing states that contributes more than 80 % of the total maize yield are Andhra Pradesh (20.9 %), Karnataka (16.5 %), Rajasthan (9.9 %), Maharashtra (9.1 %), Bihar (8.9 %), Uttar Pradesh (6.1 %), Madhya Pradesh (5.7 %) and Himachal Pradesh (4.4 %). Apart from these states it is also grown in North-Eastern states and Jammu and Kashmir. Hence, maize has emerged as important crop in the non-traditional regions i.e. peninsular India as the state like Andhra Pradesh which ranks 5th in area (0.79 m ha) has recorded the maximum production (4.14 m t) and productivity (5.26 t ha-1) in the country. (Source: Annual Progress Report Kharif Maize 2012, http://farmer.gov.in/cropstatsmaize.html)

In India, maize is cultivated on an area of 7.32 million ha with a production of 14.93 million tonnes and the productivity of 1904 kg per ha. In Karnataka it is cultivated on an area of 9.30 lakh/ha with a production of 16.2 lakh tonnes and average productivity is about 2950 kg per ha (Anonymous, 2007). Presently maize is
gaining importance in Karnataka particularly in rain fed tracts of Northern and Southern Transition zone due to its increasing demand as animal feeds and raw material for industry. Therefore, there is a need to explore the possibilities of increasing the productivity through better understanding of constraints in production.

Maize grains were used for human consumption, feed for poultry and live stock, for extraction of edible oil and also starch and glucose industry. It is called as a miracle crop with very high yield potential. It occupies an significant position in the world economy and trade as food, feed and industrial grain crop (Azizi et al., 2012). Maize is classified in to different groups based on the endosperm of kernels. It provides carbohydrates, proteins, fat, sugar, minerals and vitamins in palatable, wholesome, hygienic and digestible form. It is rich in phosphorous content (Demjanova et al., 2007).

![Fig. 5: Top 10 producers of maize in world](source: World corn production, , USDA.)
The weed problem in maize at early growth stages is very critical because they compete with the crop for required nutrients. About 50-70% yield decreased with the use of herbicide alone (Mulder and Doll, 1993). Dixit and Gautam (1995) reported that application of high doses of fertilizer during early growth of main crop promote the growth of weeds creating the problems it directly affects the crop yield. Weeds are one of the important parameter where it can cause yield reduction up to 70% by competing with main crop for nutrients (Teasdale, 1995). Herbicide applications for control of weeds cause certain amount of phytotoxicity in maize which in turn reflects in the yield. Application of over dose of herbicide draws the plants under chemical stress, as a result there is a release of free radicals of oxygen due to peroxidation of fatty acids, damaging the structure of cell membrane (Sinha et al., 2006).
Maize fields usually harbor various weed species like *Echinochloa colonum*, *Panicum repens*, *Xanthium strumarium*, *Phyllanthus niruri*, *Euphorbia hirta* and sedges like *Cyperus iria*. The weeds commonly present in soyabean fields are *Cyperus rotundus*, *Commelina benghalensis*, *Echinochloa crus-galli*, *Euphorbia geniculata*, *Merimia emeriginata*, *Phyllanthus niruri*, *Rotalla* species (Krishnamurthy et al., 1970).

Pesticides are the integral component to the farmers to control diseases, pests and weeds to enhance the crop yield. They have to apply on crops at proper time. The main purpose of application of pesticides is to increasing the plant productivity. A bundle of work has been done on the role of herbicides in providing protection to plants against weeds. Only a little work has been done on the efficacy of herbicide alachlor on persistence and residual effects. However there are no previous attempts to evaluate the effect of alachlor on soybean (DSB-21) and maize (NAC-6002). The recommended dosage of herbicide alachlor, used to control weeds may be toxic to crops also and its residue affects the succeeding crops. If the pesticide used in lower concentration they may be beneficial for plant growth, but if it is applied in high concentration it cause phytotoxicity.

Agricultural research is mainly concerned on how yield can be increased by the application of pesticides and fertilizers. Each crops showed different kinds of responses to biotic and abiotic stress. Among abiotic stress chemical stress is known to affect the metabolic processes which are involved in the plant growth and development resulting in reduced growth and yield (Rajashekar et al., 2012). Random application of herbicides for the control of weeds is a probable hazard to genetic constitution of plants. Chromosomal abnormalities may affect the growth, vigour and yield. Pesticides acts on chromosomes can cause chromosomal irregularities resulting in lethal effects and also directly affect the yield.

Hence there is a necessity to study the effect of pesticide on morphological, biochemical, cytological and yield parameters of crop plants. By keeping all these in view, the present study was taken up to evaluate the effects of herbicide alachlor on morphological, biochemical, cytological and yield parameters of soybean and maize.
The use of herbicide for weed control is an essential part of plant protection method in agriculture. Before the use of chemical herbicides cultural and mechanical practices were adopted to control the weeds. The first used herbicide was 2,4-dichlorophenoxy acetic acid. An application of herbicides induces various morphological, biochemical and cytological changes on the growth of the plants. The effects are followed by different types of injury symptoms. Different methods like mechanical, cultural, chemical and biological are used for weed control. Among these the chemical weed control methods became popular and it was found to be more effective in reducing the weed competition.