Biennial Conference of ISWS on

Weed Threat to Agriculture, Biodiversity & Environment

19-20 April, 2012

Venue : Kerala Agricultural University, Thrissur

Organizers

Indian Society of Weed Science
Kerala Agricultural University, Thrissur
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ABSTRACTS

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Content

Invited Lectures

L - 1

Knowledge sharing in agriculture with special reference to weed management

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Information is critical for accelerating the growth in agriculture. The information gap between knowledge generators and users is mindboggling. The NSSO 2005 report portrays the disturbing picture of an average of only 6% of farmers having access to new technologies through an extension agent. Today extension is in a state of decline in many states, the public extension system especially is inadequate in terms of both human and infrastructural resources. The challenges facing the agriculture today is more complex.Mere transferring technology packages are not going to be sufficient. The information package should aim at increasing the farm productivity and generate employment rather than addressing productivity issue alone. The perspective must be whole chains or even value networks. Extension should evolve to be more effective in meeting information needs of a much wider variety of clientele, including women farmers, agribusiness, rural youth, and the resource-poor farmers.

The advent of internet and the advances made in information and communication technologies (ICT) have revolutionized the way we live and communicate. Some of the major landmarks in the recent past are the world wide web (WWW), popularly known as web or internet in 1990, Google (www.google.com) in the year 1998,Wikipedia (www.wikipedia.com) in 2001, Facebook (www.facebook.com) in 2004 and Youtube (www.youtube.com) in 2005. Wikipedia is a unique digital encyclopedia where the content can be edited and commented upon by individuals. However, the content related to agriculture in Wikipedia is very limited reflecting of the lack awareness and interest amongst agricultural scientists in contributing content. In order to address this imbalance, the ICAR has launched Agropedia in 2009. Agropedia is a knowledge sharing platform developed by IIT, Kanpur under the NAIP consortium project led by ICRISAT. The agropedia portal is different from others. It is semantically enabled, multi-lingual, has a social net working site and an interface for connecting with the farmers and stakeholders. ICAR should strongly promote use of this platform for long term benefits to the country.

Courtesy new telecom policy of the union government, which enabled the participation of private parties, there has been a massive penetration of mobile phones in the country. The number is currently over 800 million and is expected to cross the billion marks by end of 2012. Competition and technology advancement have resulted in hand sets and call charges becoming affordable to the common man. With 3G round the corner, speed and access to value added information would be non-issues. An ordinary farmer or a citizen can now afford to own a mobile phone. This has greatly narrowed down the gap between the urban and rural communities, the rich and the poor and the literate and the illiterate. To a great extent, this has overcome the problem of 'last mile connectivity' and the challenges of 'reaching the unreached' - often quoted as the bottlenecks in the sphere of agricultural extension.

Agricultural knowledge management in India (AKM): ICT-enabled AKM in India is still in its infancy. Access to digital content is very limited. As on now there appears to be no concerted integrated approach in creation, holding and sharing of knowledge. Organized institutional repositories are lacking, the website of many organizations lack content, are static and are not updatedregulalry. There is absence of interaction/ sharing through wiki, blogs, discussion forums etc. organizations are not linked to social networking sites/ media. By and large, the scientists are less IT savvy and ICTs are poorly used.

Constraints in adoption of ICTs: Some common problems in the adoption of ICT in agriculture are; poor and inadequate infrastructure, absence of digital content in local languages, lack of interest in sharing & collaboration, poor IT culture, lack of enabling policies and old mindset relating to sharing of information.

The way forward; The IT industry will continue to come up with more and more affordable ICT tools and technologies which would simplify our lives and would help in accelerating growth in all fields including agriculture. The challenges will be with popularizing and customizing them to our local needs. NARS should develop long term collaboration with the IT institutions and the IT industry to achieve this. NAIP has made huge investments on ICT projects and some very good outputs and outcomes are already visible. The impacts will be felt in the next 3-5 years. What is badly needed is the mobilization of the public and sensitization of senior managers & policy makers, capacity building of scientist and stakeholders and extension personnel.

L - 2 Herbicide resistance in India : current scenario and prospects

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In the last century herbicide resistance was reported in two major crops in India, wheat and tea plantations to PSII (isoproturon) and PSI (paraquat) inhibiting herbicides. Out of the two, the first one got notoriety due to resistance in *P. minor* – a major weed of several continents. Paraquat resistance was not wide spread and alternate herbicides (glyphosate, 2-4-D, carfentrazone; alone and as tank mixture) were effective to contain the economic damage. *P. minor* emerged as the most pernicious weed of wheat in NW-India under rice-wheat cropping system and also a nuisance in adjoining countries (Pakistan, Iran, Nepal, and others) with the potential to cause significant yield penalty in wheat and other winter season crops. It was controlled successfully by isoproturon for over a decade, before resistance was observed in 1991-92. The resistance was characterized as metabolic one- which has the potential to render herbicides of other groups also useless, if not used judiciously. Cross-resistance in Isoproturon-resistant populations quickly evolved to diclofop-methyl followed by fenoxaprop-P-ethyl and lately to clodinafop-propargyl. Recent studies indicate that *P. minor* biotypes have acquired multiple resistance mechanisms (target site and enhanced metabolism) offering a challenge to weed scientists in its management. Resistant populations of *P. minor* have also been observed in South Africa, Iran, Israel, Mexico and USA to herbicides of different modes of action.

Presently there is no recommended herbicide in India without problems. Regeneration of *P. minor* under field conditions is the major cause of concern with all the recommended herbicides followed by emergence of several flushes in the same growing season. Weather plays a significant role on the efficacy of herbicides along with application time and methods for the control of *P. minor*. The present paper will discuss the role and scope of rotation of crops, herbicides and agronomic practices, use of herbicides in mixture and their sequential application (PRE followed by POST) as well as repeat application of herbicides. An integrated approach combining the knowledge of weed biology, methods of field preparation, selection and seed rate of wheat variety, planting time, rate and method of herbicide application, use of surfactant, and avoidance of weed seed spread to other areas through several mechanisms are needed to contain and delay resistance evolution to herbicides of newer chemistries.

L - 3

Weed management in conservation agriculture systems: problems and prospects

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Conservation agriculture (CA) has drawn the attention of resource management scientists throughout the globe since early 1970s, following widespread resource degradation problems and rise in energy prices. Over the last 20 years, major gains from the adoption of these technologies have been realized in many countries of America and Australia. It is estimated that > 120 million ha of the cropped area is under conservation agriculture systems in countries like USA, Canada, Australia, Brazil, Argentina, Australia as well as in some Asian and European countries. In south Asia including India, some initiatives were undertaken since early 1990s to develop resource conserving technologies in rice-wheat cropping system. Presently, about 3 million ha of wheat is estimated to be grown under zero-tillage conditions.

Conservation agriculture technologies involves minimum soil disturbance, providing a soil cover through crop residues or other cover crops, diversification of species and sensible crop rotations. In the conventional agricultural systems involving intensive tillage, there is a gradual decline in soil organic matter through accelerated oxidation and burning of crop residues. When the crop residues are retained on soil surface in combination with zero tillage, several changes occur that lead to improved soil quality and overall resource enhancement. Therefore, the CA technologies lead to sustainable improvement in the efficient use of water and nutrients by improving nutrient balances and availability, infiltration and retention by soils reducing water losses, and improving the quality and availability of ground and surface water.

Tillage influences weed infestation, and thus interactions between tillage and weed control practices are commonly observed in crop production. Adequate tillage checks and delays emergence of weeds, and provides a more favourable environment for early crop establishment. Available reports suggest that zero tillage increases as well as reduces infestation of certain weed species in different crops. In rainy season when the weed problem is generally more, growing crops with zero tillage require additional measures for effective weed control, including use of non-selective herbicides like paraquat and glyphosate. Zero-till sowing in standing crop residues along with application of herbicides in proper combination, sequence or in rotation leads to lower weed population and higher yield than conventional planting. Therefore, integrated weed management options are essential for effective weed control under modified tillage and crop establishment practices.

Changing from conventional tillage-based farming to zero-till farming is not easy. The difficulty of the transition, together with the common perception that zero-till incurs a greater risk of crop failure or lower net returns than conventional agriculture, has seriously hindered widespread adoption of this approach in countries outside North and South America. Yields of zero-till crops are often reduced by 5-10% especially on fine-textured, poorly-drained soils, compared with conventional tillage. Further, zero-till may require application of extra N fertilizer and reliance on herbicides to control the weeds. Herbicide-resistant weeds are already becoming more common on zero-till farms in some countries. Therefore, the continued adoption of zero-tillage based farming system is highly dependent on the development of new herbicide formulations and integrated weed management options.

L - 4 Major weeds and their management in Tamil Nadu

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Tamil Nadu in the southern most part of India lies between the Bay of Bengal in the east and Western Ghats in the west. There are many factors that cause reduction in yield, the maximum loss of 45 per cent is caused only by weeds. Weeds caused 69 per cent yield loss in rice, 34 per cent in wheat, 50 per cent in pulses, 72 per cent in sugarcane and almost 90 per cent in vegetables. The total world food loss due to weeds is estimated to be 33% of 287 million tonnes due to total pest incidence, which accounts for 11.5 per cent of the total food production. In Tamil Nadu, a yield loss of rice is around 111.81 thousand tonnes per year due to weeds alone. The major weeds of rice ecosystems in Tamil Nadu were *Echinochloa crusgalli* (22.0 %), *Echinochloa colona* (23.5%) in grasses, *Cyperus difformis* (21.3%) and *Cyperus iria* (21.0%) in sedges, *Marsilea quadrifoliata* (5.8%) and other broad leaved weeds (6.4 %) during *Rabi* seasons. In general broad leaved weeds are predominant weed flora accounting for 43.2% of total weed flora followed by grasses (29.8%) and sedges (26.9%) in transplanted rice. In garden land ecosystems of Tamil Nadu, *Trianthema portulacastrum*, *Amaranthus viridis*, *Parthenium hysterophorus*, *Echinochloa* sp. *and Cyperus* sp. were dominant weeds. *Cyperus rotundus* (40.03%), *Portulaca oleraceae* (17.77%), *Cynodon dactylon* (13.70%), *Echinochloa columum* (10.00%), *Convolvulus arvensis* (9.25%), *Digeria arvensis* (3.70%), *Euphorbia hirta* (1.85%), *Amaranthus viridis* (1.85%) and *Corchorus olitorius* (1.85%) were the major weeds in winter season. In dry land ecosystems of Tamil Nadu, diverse weed flora was observed in moisture stress ecosystems. Predominant weeds were *Andropogan contortus, Cynodon dactylon, Panicum* sp*, Achyranthus aspera, Amaranthus viridis, Borreria hispida, Celosia argentia, Leucas aspera, Ocimum canum, Phyllanthus niruri, Phyllanthus maderaspatensis, Euphorbia hirta, Boerhaavia diffusa, Cynotis cuculatta, Digera arvensis* and *Cyperus rotundus.* Major weeds of wetland ecosystem can be managed by pre-emergence application of butachlor 2.0 l/ha (or) thiobencarb 2.0 l/ha (or) pendimethalin 2.5 l/ha (or) anilophous 1.25 l/ha along with one hand weeding on 35 DAP. In millet crops like maize, sorghum, pearl millet and finger millet, the predominant weed flora can be managed by the pre-emergence application of atrazine 0.5 kg/ha with one hand weeding. Pre-emergence application of alachlor 1.25 kg/ha (or) pendimethalin 1.0 kg/ha with one hand weeding gave effective control of weeds in major pulse crops in Tamil Nadu. Pre-emergence application of pendimethalin 1.0 kg/ha (or) oxyflourfen 200 g/ha followed by one hand weeding will be a best weed control options for oil seed crops like groundnut, sesame, sunflower *etc.*, Pre-emergence herbicides *viz*., pendimethalin 1.0 kg/ha (or) fluchloralin 1.5 lit/ha (or) oxyflourfen 0.2 kg/ha + metolachlor 1.0 kg/ha sprayed on 3 DAS followed by one supplementary manual weeding at 40 DAS proved to be the best weed control method for cotton. Predominant problematic, parasitic and aquatic weeds were, *Cynodon dactylon, Cyperus rotundus* and *Parthenium hysterophorus* and *Orobanche* spp, *Striga* spp, *Dendropthoe* spp and *Cuscuta* spp. *Orobanche* being complete parasite occurring on to-bacco, tomato, brinjal, potato *etc.,* Striga being partial parasite occurring on sorghum, maize, sugarcane and *Cuscuta* being partial parasite occurring on lucerne, bengal gram and plantation crops. *Dendropthoe* being partial parasite occurring on fruit trees and plantation crops. *Eichhornia crassipes* is the most troublesome aquatic weed distributed in lakes, rivers, ponds and ditches. Pre-emergence atrazine 1.0 kg/ha on 3 DAP + POE spraying of 2,4-D Na salt at 5 g + urea 20 g/litre of water on 90 DAP effectively reduced the density and dry weight of *Striga asiatica* with better weed control efficiency. PE pendimethalin 1.0 kg/ha + plant hole application of neem cake 200 kg/ha on 30 day after transplanting direct contact application of imazethapyr 30 g/ha on 55 DAT and crop rotation with pulses (or) sesame (or) sorghum reduced the infestation of *Orobanche*. Non-selective herbicide like paraquat (1% spray) and glyphosate (1%) and others like 2,4,D kill *Cuscuta* effectively in area where *Cuscuta* occurs in pathches. Use of pre-emergence herbicide like fluchloralin, trifluralin or pendimethalin at 0.75 to 1.50kg/ha will lower the menace of *Cuscuta*. Plant hole application of 8 g copper sulphate and 1 g 2,4-D powder, free the trees from *Dendropthoe* for four years.

L - 5 Successful biosuppression of *Salvinia molesta* using *Cyrtobagous salviniae* in Kerala

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Salvinia molesta Mitchell is a non-flowering plant of South American origin. The weed infestation occurred in nearly 7,150 sq. km. out of a total area of 38,900 sq. km. of the State. It is estimated that this molesting weed affects the daily life of about five million people in Kerala. Spilling on them, they lay waste fertile fields, enhance cost of cultivation, reduce crop yields, clog canals and water ways, impede navigation, irrigation and fish production, choke intake screens of hydroelectric projects, spread diseases and interfere with recreation pursuits and even domestic washing.

For suppression of the weed the weevil *Cyrtobagous salviniae* Calder & Sands was introduced in to Kerala, from Australia. Conducted studies on the biology and morphology of the insect. Eggs are inserted singly at the base of leaves and in scars of rhizomes. Freshly laid eggs were pale yellow in colour which gradually darkened during development. The incubation period varied from six to nine days. On hatching, the first instar larva remained outside for a while scraping on the tender plant tissues. After about three to four days they tunneled in to the leaf base on the nodal region of the rhizome and completed the three instars in 28 days. Pupation took place in a spun cocoon and adult lived for 172 to 279 days. Due to feeding of the larvae, the leaves become characteristically darkened, resulting in death and disintegration of plant tissues. The major damage was caused by tunneling of the rhizome by the larvae. Adults fed on unopened leaf buds and tender leaves. Because of their feeding, circular holes were formed on the buds and leaves. The visible symptoms of attack by *C. salviniae* are gradual change of colour from normal green to yellowish green, and then to rusty brown. The leaf size and root length got gradually reduced and finally the weed turned in to brownish black mass.

Field experiments were carried out in three districts of Kerala. In all the areas weevils were established and suppressed the weed. In monsoon floods, the weevil infested weed along with the insect was carried to distant places. The insect thus reached all the nooks and corners of Kuttanad. Regrowth appeared in stagnant side canals, small ponds and a few paddy fields. Within a month after appearance of the regrowth, the weevil also appeared and kept the growth under check. Wheresoever *C. salviniae* weevils exist, this condition of coexistence is likely to prevail and there is hardly any chance of total eradication neither the weed nor the natural enemy. This phenomenal biological suppression has been accomplished over a wide area of 1000 km^2 in the comparatively short period of two years. The weevil has remained strictly host-specific to the target plant. The weed suppression obtained is above ninety per cent in Kuttanad. Occasionally weed regrowth has been noticed; but it has perished in 8 to 12 months. The farmers of Kuttanad and kole lands have benefited immensely by the weed suppression. From the 29,000 hectares of paddy fields in Kuttanad alone, the reduction of weed damage has saved Rs. 6.8 million per year. The once chocked navigation canals have been cleared for transportation. Thus Kuttanad and kole lands, the granaries of Kerala, have been cured of a grave cancer gnawing into the economy of the State.

L - 6 Nanoherbicide : a new tool in modern weed management

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Presently thousands of herbicide formulations are available in the market to combat weed plants under diverse situation. In 2002, global herbicide sales were nearly US$28 billion, constituting 47% of the total agrochemicals used worldwide. With respect to India the consumption has increased rapidly from 4100 metric tonnes (MT) in 1988-89 to 11,000 MT in 2001-02 and it is likely to further increase in future. It is estimated that the herbicide market would grow at over 10 % per annum. (NRCWS)

Although herbicides will continue to be the dominant technology in weed management programs, several problems have arisen from reliance on herbicides including herbicide movement to non-target areas, environmental contamination, and development of herbicide-resistant weeds. Continuous exposure of plant community having mild susceptibility to an herbicide in one season and different herbicide in another season develops resistance to all the chemicals in due course and become uncontrollable through chemicals. The performance of herbicides in tropical environments can sometimes be erratic and inefficient. This is particularly true for soil-applied herbicides where high temperatures, intense rainfall, low soil organic matter and microbial activity results in rapid breakdown and loss through leaching. Further the the irrgation process reduces the herbicide concentration lead to reduced weed control efficiency coupled with leaching and potential ground water pollution. Thus the half life period for many soil herbicides remains very short period of time ranging from few hours to couple of weeks. Whereas some of the herbicide parent material persist in soil for long time and results in residual toxicity problems. Among the herbicides, atrazine is almost a non-volatile and its half-life in neutral condition varies from 4-57 weeks depending on various environmental factors like pH, moisture content, temperature and microbial activity. Although, there are different methods (by activated carbon adsorption, microbes or air stripping) for removal of atrazine residues from aquatic system, there are no established methods for the vast soil phase. Furthermore the herbicides available in the market are designed to control or kill the germinating or growing above ground part of the weed plants. None of the herbicides are inhibiting the viable underground propagating materials.

Hence it is evident that the task is huge and solutions are limited. Amidst this situation, the new science, nanotechnology throws rays of hope for the development of nanoherbicides with highly specific, controlled release and increased efficiency to circumvent the weed competition under different ecosystem of crop production. Nanotechnology is a technology having the potential ability to study, design, create, synthesis, manipulation of functional materials, devices, and systems to fabricate structures with atomic precision by controlling the size of the matter at the scale 1–100 nanometers (one nanometer being equal to 1×10^{-9} of a meter). The properties and effects of nanoscale particles and materials differs signi?cantly from larger particles of the same chemical composition. By controlling structure precisely at nanoscale dimensions, one can control and tailor properties of nanostructures, such as nanocapsules, in a very accurate manner for slow release herbicide to achieve season long weed control. Degrading phenolic compounds responsible for dormancy of weeds with suitable functionalized nanoparticle would be an intelligent solution for the exhausting the weed seed bank. Despite their minuscule size, the zero Valent Iron (ZVI) nano particle, a chemical reductant hold the potential to cost-effectively address the issue of atrazine residual toxicity. Hence with the advancement of science in nano-scale level, vast scope is ahead for the weed scientist to resolve the problems encountered in weed management without hampering the natural ecosystem.

L - 7

Major weeds and their management in Gujarat

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Agriculture is the mainstay of Indian economy. Weeds endanger biodiversity, affect human and animal health, aquatic ecosystem and grasslands. The problems due to weeds are more evident in the era of modern agriculture due to the large scale use of high doses of fertilizers and irrigation in major crops grown in India. Weeds are a big constraint in crop production and are responsible for heavy yield losses in almost all the crops grown in Gujarat. *Eragrostis major*, *Digitaria sanguinalis*, *Dactyloctenium aegyptium*, *Eleusine indica*, *Echinochloa crusgalli*, *Echinochloa colona*, *Setaria glauca*, *Cyperus rotundus*, *Cynodon dactylon* and *Commelina forskalaei* as monocot weeds while, *Trianthema monogyna*, *Boerhavia diffusa*, *Phyllanthus niruri*, *Digera arvensis*, *Parthenium hysterophorus*, *Amaranthus lividus, Amaranthus viridis*, *Convolvulus arvensis, Oldenlandia umbellata, Celosia argentea* and *Physalis minima* as broad leaved weeds noticed as major weeds in *Kharif* crops grown in Gujarat. *Asphodelus tenuifolius*, *Chloris barbata* and *Eleusine indica* as monocot weeds while, *Chenopodium album*, *Boerhavia diffusa*, *Portulaca quadrifida*, *Meliotus indica* and *Chenopodium murale* as broad leaved weeds noticed as major weeds in *Rabi* crops grown in Gujarat.

Results of the experiments carried out at various centres showed that fluchloralin, trifluralin, pendimethalin and atrazine 0.5 to 1.0 kg/ha were highly effective in controlling *Trianthema monogyna, Setaria glauca, Digitaria sanguinalis*, *Dactyloctenium aegyptium* and *Eleusine indica* along with other major weeds in *Kharif* and *Rabi* crops while, *Convolvulus arvensis, Parthenium hysterophorus, Cynodon dactylon* and *Cyprus rotundus* were controlled by post emergence application of glyphosate or glufosinate ammonium. *Asphodelus tenuifolius* was controlled 80 to 90 % by metribuzin 0.70 kg/ha as pre-emergence, while more than 90 % control achieved with the pre emergence application of atrazine 0.50 kg/ha.

On the basis of screening of various herbicides and other weed management practices tested in major crops, pendimethalin 0.5 to 1.0 kg/ha is recommended for weed management in major crops grown in Gujarat *viz;* cotton, groundnut, tomato, chillies, okra, onion, paddy and tobacco nursery, cumin, cluster bean, soybean and wheat. Application of atrazine 0.5 to 1.0 kg/ha is recommended for weed management in sorghum, pearl millet, maize and sugarcane. Post emergence application of quizalofop-ethyl or fenoxaprop-p-ethyl 100 g/ha is most effective and recommended for control of grassy weeds in groundnut and soybean.

Among problematic and parasitic weeds, post emergence application of glyphosate 0.50 to 0.75 kg/ha showed 38 to 50% mortality of *Cyperus rotundus,* while application of glyphosate 1.0 to 1.5 kg/ha showed 68 to 96% mortality of *Cyperus rotundus.* In non cropped situation, broadcasting of *Cassia sericea* or *Cassia tora* 15 kg/ha in the month of June was effective to manage Parthenium in non cropped area. Post emergence application of glyphosate 2.4 kg/ha was also effective to manage *Parthenium hysterophorus* in non-cropped situation. Application of pendimethalin 0.5 kg/ha at 10 days after sowing is recommended in forage lucerne crop for control of parasitic weed *Cuscuta.*

L - 8

Current status of weedy rice in India and strategies for its management

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Weedy rice is a complex of *Oryza* morphotypes widely distributed in the commercial rice fields in more than 50 countries of Asia, Africa and Latin America, especially in areas where farmers have switched to direct seeding due to labour shortage and high cost. India is the centre of origin of rice, and many wild and weedy relatives are seen in the rice growing areas of the country. Introgressions between perennial wild rice and cultivated rice have given rise to highly variable population of weedy/wild rice types, including annuals and perennials. Indian weedy rice belongs to the *indica* group and weedy species in cultivated rice is reported to be *Oryza sativa* f.sp. *spontanea.* Heavy infestation of weedy rice in rice fields of Kerala during recent years is forcing farmers to abandon the crop due to huge reduction in crop yield around 30-60 per cent depending on the severity of infestation (3-10 mature weedy plants per square meter). Variations in plant height, tiller production, pigmentation, length of awn and grain are noticed in the wild and weedy rice types of India. Heavy infestation of weedy rice ecotypes in rice fields is a problem in eastern India (eastern U.P., Bihar, Orissa, Manipur and West Bengal) and southern India. Whereas, in north western states like Haryana and Punjab wild rice is not yet a problem (AICRP, 2010).

Efficient management of weedy rice infestation is complex because of its morphological similarities which makes it difficult to distinguish weedy rice from cultivated rice till it comes to flowering, variable dormancy, staggered germination, high competitiveness and early seed shattering. Weedy rice come to flowering much earlier than cultivated rice and produce grains having awns, with varying pigmentation for ear head. Seeds mature within a short period and shatter immediately facilitating the buildup of weed seed bank before the farmer gets a chance to remove the seeds along with the harvest of rice crop. Number of studies have been done at the molecular level where shattering ability was zeroed down to differentiation of abscission layer and the locus identified for it. Later it was found that the inactivation of the CTD phosphates like gene OsCPL1 enhances the development of abscission layer and seed shattering in rice. Studies have shown that seeds often germinate between 15 to 40ºC and many seeds decay between long periods of flooded condition. Most of the seeds germinate from the upper 0-4cm layer of soil. Dormancy in weedy rice is highly correlated with awning, black hull and red pericarp. Characters like higher Nitrogen use efficiency for biomass production, high and early seed shattering, asynchronous maturity, etc are some of the major parameters responsible for its weedy trait.

Morphological as well as physiological peculiarities of weedy rice make hand weeding incomplete and ineffective. As no single technique can effectively control weedy populations under field conditions, its infestation is a menace in commercial rice fields. As the present recommendations of chemical weed control in rice are not effective for selective control of weedy rice, suitable package for integrated management of weedy rice is to be evolved for increasing the production and productivity of rice. The best method for preventing the infestation is the use of clean seeds. In already infested fields, the strategy is to deplete the weedy rice soil seed bank by various methods like burning of straw left after the harvest of rice to destroy the seeds lying on the surface, stale seed bed technique (removing the germinated weedy seeds mechanically or using non selective herbicides before planting), or by direct contact application of nonselective herbicides like paraquat, glufosinate, glyphosate *etc.,* using special applicators to the ear heads of weedy rice which will selectively dry the panicles. Among the different pre-emergence herbicides tried, surface application of oxyfluorfen 0.3 kg/ha in 2 inches of standing water (after land preparation and three days before sowing of rice crop), effectively controlled weedy rice during the initial critical period of 12-15 days. Rotation of rice crop with other crops for a few seasons can also free the field from weedy rice infestations. Effective eco friendly management of weedy rice is possible by following other management options like higher seed rate, use of pigmented rice varieties, straw burning, appropriate tillage practices, adoption of mechanized transplanting or dibbling, scientific water management, and hand weeding in an integrated approach.

Biotechnological approaches using genetically modified herbicide tolerant rice varieties may be an efficient strategy in the control of weedy rice. A non transgenic rice variety 'Clearfield' tolerant to herbicide imazethapyr has been in use in red rice infested fields of United States of America since 2002. However, the possibility of out crossing of the resistant variety with wild rice is suspected to taint the advantage of this technology. Efforts to understand and figure out the genesis of weedy rice in India by comparing the genetic backgrounds of different weedy rice biotypes with wild and cultivated rice have been made at the Directorate of Weeds Science Research, Jabalpur. Seventy five weedy rice biotypes across 6 states have been collected through survey and help of AICRP-Weed control centres. A comprehensive study of all these biotypes, wild rice and cultivated rice. Molecular fingerprinting by microsatellites is also planned and work has already been initiated in this direction.

L-9 Alternative weed management options through farming elements

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Smaller farm holdings in Asia offers scope for using component elements in a farming system for sustainable management of weeds that behave invasive in a changing climate. Altered precipitation, evaporation and temperature patterns due to climate change have resulted in weed flora shifts in northern coastal districts of Tamilnadu state, India. In particular, there has been a preponderance of invasive alien species such as *Leptochloa chinensis* (L.) and *Marsilea quadrifolia* L. in wetlands, *Trianthema portulacastrum* L. in uplands and *Eichhornia crassipes Mart. Solms* in aquatic systems. Management of these weeds is constrained by lack of efficient control by independent approaches like manual or chemical measures. Hence, integrated approaches involving cultural measures assume importance. Research undertaken at Annamalai University in India is providing some alternative solutions to manage these problematic weeds. Innovative use of fish culture and poultry rearing in rice fields was shown to compliment weed control through 400 on-farm experiments, with biomass reductions of invasive alien species ranging from 31 to 38 per cent, in these districts. Similarly, using goats for off-season grazing reduced the biomass of weeds in upland crops. For example, biomass of the dominant *T. portulacastrum* declined by 23 to 29 per cent in 500 on-farm participatory experiments. Involving pigs for burrowing the puddled fields and addition of Tamarind husk complimented control of rice weeds especially nut sedge, which was reduced by 61 per cent. The invasive weed *E. crassipes* in aquatic systems was controlled in seasonal waterbodies within a season, by innovative and integrated use of insect agent (*Neochetina eichhorniae*) and plant product of *Coleus amboinicus* L. Utility modes for consuming the extensive biomass of *E. crassipes* have also been compared (*viz.,* manure, cattle feed and nanofiber extraction). Results indicate that manurial use and tempo mediated extraction of nanofibers offers an innovative tag of utility for management of this weed.

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Major crop weeds and their management in Haryana

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Haryana, a small state with geographical area of 44000 Km^2 is the second largest contributor of wheat and rice to the central pool after Punjab. Although, Haryana tops the nation in productivity of wheat and mustard, but average yield of all the crops is low compared to developed countries. Losses due to weeds is one the major biotic constraints for realizing potiential yields. Use of particular group of herbicides over a long period of time particularly in rice, wheat, sugarcane and maize has led to shift in weed flora also. Infestation of some weeds like *Solanum nigrum*, *Malva parviflora*, *Polypogon monspeliensis* and *Poa annua* in wheat, *Ammania baccifera* and *Saggitaria guanensis* in rice, *Orobanche aegyptiaca* in mustard and tomato, *Euphorbia dracunculoides, Convolvulus arvensis and Asphodelus tenuifolius* in chickpea is increasing every year. So, knowledge of weed species associated with crops in a region is necessary for planning an effective weed control programme.

Phalaris minor, *Rumex dentatus*, *Coronopus didymus*, *Chenopodium album*, *Medicago denticulate* and *Melilotus indica* are the major weeds of wheat grown after rice in north-eastern districts and western parts of state, whereas wheat grown after cotton and pearl millet in south-western districts is infested with both grassy and broadleaf weeds such as *Avena ludoviciana* and *P. minor* as grassy and *C. album*, *C. murale*, *M. indica*, *C. arvensis*, *R. spinosus*, *Fumaria parviflora* and *Trigonella polycerata* as broadleaf weeds. Rice crop is infested with *Echinochloa colona, E. glabrescence*, *Ammania sp., S. guanensis*, *Cyperus difformis* and *C.iria*. In sugarcane, infestation of *Dactyloctenium aegypticum, D. sanguinalis, E.colona, E. glabrescence*, *Trianthema portulacastrum*, *Ipomoea spp*, *Physallis minima*, *Conyza canadensis*, *Cyperus iria* and *Cynodon dactylon* is more common. *A. tenuifolius C. album, M. indica, Trigonella polycerata, C. murale, Cynodon dactylon, O. aegyptiaca, A. ludoviciana and C. arvensis* are highly associated with mustard crop. *Digera arvensis, Trianthema portulacastrum, Cyperus rotundus, Physallis minima, D. aegypticum, Corchorus tridens, and Cucumis callosus* are important weeds found to infest clusterbean and cotton crops in Haryana. *C.rotundus. A. arvensis, C. album, M. indica, C. didymus, M. denticulata* and *Spergula arvensis* among broadleaf weeds & *P. minor, P. annua* and *P. monspeliensis* among grasses are the major weeds infesting garlic and onion fields in the state.

Use of herbicides like clodinafop, sulfosulfuron, pinoxaden, meso+iodosulfuron (R.M.) and sulfosulfuron+metsulfuron (R.M.) are very effective to control weeds in wheat whereas in rice pre-emergence herbicides like butachlor, pretilachlor, oxadiargyl, anilfos and bispyribac(post) are recommended. Pre-emergence use of pendimethalin at 1.0 kg/ha or pre-plant incorporation (PPI) of trifluralin at 1.0 kg/ha along with one hoeing provides effective control in cotton while use of atrazine at 2.0 kg/ha after first irrigation and hoeing takes care of most of the weeds in sugarcane. Pendimethalin 1.5 kg/ha (PRE), early post emergence use of oxadiargyl at 100 g/ha and oxyfluorfen (post emergence) at 150-200 g/h are recommended to control weeds in onion and garlic.

L - 11

Biological control of weeds through fungal pathogens: Indian perspectives

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Herbicides have played a vital role in improving crop productivity. Due to the recent trends in environmental awareness concerning the side effects of herbicides, public pressure is mounting to force industry to develop safer, more environmental friendly approaches for controlling weeds. Biological weed control with plant pathogenic fungi used as mycoherbicides offers such an approach. Considerable progress has been made during the past three decades in the use of fungi as mycohercicides. 3

There has been a great number of naturally occurring fungal strains researched for possible use as mycoherbicides, but only a small proportion (i.e. 16) have been developed to commercial products. Currently, a total of 16 mycoherbicides (7 in the USA, 4 in Canada, 2 in South Africa and one each in Netherlands, Japan and China) have been registered around the globe. Some mycoherbicides have been registered but are not available in the market due to several biological and environmental limitations which must be overcome before they will be widely acceptable for practical use.

The advancement of formulation techniques is of paramount importance to the continued development of mycoherbicides. It is also essential to continue intensive screening programs for the selection of fungal pathogens, especially hemibiotrophs, if mycoherbicides are to become a viable component of integrated weed management in the future. Recent trend is the application of several host-specific fungal pathogens in a bioherbicide mixture as a multi-component bioherbicide system for simultaneous, broad-spectrum weed biocontrol. Weed control with fungal biocontrol agents is being carried out at several laboratories in India. The notable of these are at Jabalpur (M.P.), Thiruvananthapuram (Kerala), Bangalore (Karnataka), Kurukshetra (Haryana), Annamalai and Madurai (T.N.). At Kurukshetra, during the last 30 years, searches for fungal BCAs have been made on 26 weeds (7 aquatic and 19 terrestrial).

Of the several fungal pathogens reported on these weeds, a number of them, have been evaluated for their biocontrol potential against the notorious weeds of this region. *Gibbago trianthemae, Alternaria alternata* and *A. eichhorniae* have shown all the desirable characteristics to be present in a successful biocontrol agent for controlling *Trianthema portulacastrum* and *Eichhornia crassipes* and there is a possibility of developing these fungi as mycoherbicides in India in the near future.

L - 12 Sanitary and phytosanitary measures and issue of invasive alien species

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The year 1995 saw the birth of the youngest International Organisation by name WTO (World Trade Organisation) to deal with the global rules of trade between nations. WTO and its predecessor GATT (General Agreement on tariffs and Trade) were aimed at regulating global trade and to ensure smooth and free flow of trade between countries. Undoubtedly they promoted trade and merchandise exports grew at an annual rate of 6%. However with this expansion in trade there has been an increased movement of species to new locations – potential invasive aliens.

Vessels of transport, equipment and machinery, packaging material, agricultural produce, timber, international mail *etc.,* are some of the unintentional means of introduction of alien species while introduction for research in agriculture, forestry, biological control and smuggling could lead to intentional introduction of new species which may become future threats to the environment, ecology, agriculture and even food production. The economic losses due to Invasive alien species (IAS) can be huge.

Invasive alien species (IAS) not only affects environment, production and productivity but also the export markets of countries. Imports from countries can be banned for presence of pests or diseases and also for not adhering to quality standards. Prevention measures though costly thus becomes essential.

The WTO is an organization for trade opening and negotiation of trade agreements. It is a place for countries to settle trade disputes. Since WTO came into being tariffs have come down drastically thus opening up markets for trade. Under the WTO there are several agreements of which the Agreement on Sanitary and Phytosanitary measures (SPS) is the one applicable to IAS. SPS sets out the basic rules to ensure food, plant and animal safety and prevention of entry of unwarranted species through trade.

Regulations under the purview of the WTO-SPS Agreement include:

- the protection of animal or plant life or health within a territory from risks arising from the entry, establishment, or spread of pest, disease, disease-carrying organisms, or disease-causing organisms.
- the protection of human or animal life or health within a territory from risks arising from additives, contaminants, toxins, or disease-causing organisms in foods, beverages, or feedstuffs.
- the protection of human life or health within a territory from risks arising from diseases carried by animals, plants, or products thereof, or from entry, establishment, or spread of pests.
- the prevention or reduction of the risks of other damages within a territory from the entry, establishment, or spread of pests

SPS allows countries to set their own standards supported by risk assessment and scientific evidence. Since WTO is mainly intended for trade promotion, it insists that SPS standards should be applied only to the extent necessary to protect human, animal or plant life or health and must not become a trade barrier or create any discrimination between nations.

Member countries are encouraged to use international standards, guidelines and recommendations where they exist. When they do, they are unlikely to be challenged legally in a WTO dispute. However, members can set higher standards based on appropriate assessment of risks so long as the approach is consistent, not arbitrary. And they can to some extent apply the "precautionary principle", a kind of "safety first" approach to deal with scientific uncertainty. The disputes raised by Philippines regarding importation of fresh pineapple into Australia and by Canada on import of salmon into Australia are some of the relevant cases. A case on the alleged EC moratorium on biotech products has also been considered by the WTO Appellate Body.

L - 13 Role of resource conservation technologies in weed management

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Conservation Agriculture (CA) based resource conservation technologies (RCTs) can play an important role in reducing the cultivation cost, improving soil carbon build up and reducing the water runoff and soil erosion besides improving the irrigation water productivity, input use efficiency, resource base and environment. CA has steadily increased worldwide to cover about 7% of the world arable land (108 m ha). In North west India including Haryana, research and extension efforts are focused on the evaluation and accelerated adoption of many CA based RCTs like zero tillage and long-term zero-tillage in different crops and cropping systems, double no-till and even triple no-till (no cultivation in three crops in sequence in a year), direct seeding and mechanical transplanting of rice, LCC, laser leveling, surface seeding, stale bed technique, infusion of moong bean between rice and wheat, green/brown manuring, relay cropping of moong bean in wheat and wheat in cotton, sugarcane based intercropping and crop diversification through bed planting, dual purpose wheat and barley, herbicide resistance management, improved spray techniques, residue management, controlled traffic, cover crops, seed priming, genotype suitability, grain quality improvement, machinery up- gradation and refinement etc. Most of the aforesaid RCTs are catching interest of growers in one or other part of NW India. Herbicide resistance in *Phalaris minor* is still perceived as most serious issue by wheat growers and this had actually triggered the interest of growers to consider adoption of many emerging RCTs. Instead of opting for any new cultural practices, most of the farmers still depend on herbicides for which the choice is now limited. Early sowing of wheat combined with zero tillage technology has been well accepted by farmers. In Haryana, 11 to 14 years long- term zero-tillage in different cropping systems (rice-wheat, pearl millet-wheat and sorghum-wheat) revealed that the grain yield of wheat under zero-tillage stayed = the conventional method due to earlier/ timely planting, fewer weeds, better plant stand and improved fertilizer efficiency.

ZT helps reduce 30-40 % emergence of *Phalaris minor* in wheat and continuous adoption of this technology has provided an opportunity to skip off herbicidal application at least once after 3-4 years at few locations. Avoiding stubble/straw burning and by opting improved herbicide application practice (alternate herbicides, herbicide rotation, improved spray techniques) could reduce pressure of weeds in different crops. Rice and wheat residues (7-8 t/ha) when burnt instantly generate as much as 13 tons of CO_2 /ha, contaminating the air, depriving soils of organic matter, and constraining supplies of fodder for livestock. About 400 million tones of crop residues are produced annually in India, and if it is somehow managed properly preferably *in situ* (mulching on soil surface) by using second generation machinery (Happy/Turbo seeder), can significantly reduce weed infestation besides improving soil health. The bed planting can be used to improve the water productivity, as well as introducing intercropping and diversification (as done very successfully in sugarcane based cropping systems) and non-chemical weed control. After laser leveling, it has been reported that yield remains same or is enhanced from 10 to 25 %, water saving by 10-15 %, a significant reduction in weeds (40%) and labour requirement for weeding (75%) and an increase in the cultivable area by 5 to 7%. Proper land leveling is a pre-requisite for the success of various RCTs particularly bed planting and direct seeded rice. Direct seeded rice (DSR) being cost effective, more water-efficient, less labor-intensive and eco-friendly is also being advocated for accelerated adoption in NW India particularly in Haryana and Punjab. However, weed pressure particularly of aerobic grassy weeds like *Leptochloa chinensis, Eragrostis tenella* and *Dactyloctenium aegyptium* along with other grassy and broadleaf weeds, and sedges remains more in DSR than transplanted rice. But, suitable herbicidal combinations integrated with other methods of weed management are now available to tackle the well realized and complex problem of weeds in DSR. Mechanical transplanting of rice in unpuddled and no-till situations has also been recommended in Haryana as an alternate to manual puddle-transplanting. Green/brown manuring, cover crops, relay crops and competitive genotypes may also be integrated while formulating effective weed management strategies. The paper will include current status of different RCTs, their multifarious impacts and future implications with special reference to their role in weed management.

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Major weeds and their management in Punjab

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Punjab is an agrarian state. Rice-wheat cropping system dominates the state agriculture followed by cotton-wheat, maize- wheat and sugarcane-wheat cropping systems. Out of total cropped area of 7.9 million ha, wheat and rice account for 44.5 and 35.4%, respectively; the corresponding figure is 6.2% for cotton, 1.7% for maize, 1% for sugarcane, 0.7% for pulses and 0.6% for oilseeds. As 97% of the state cropping area is irrigated, weeds emerge at higher densities and pose major competition with the crop plants and 20-25% losses in economic yields are quite common. The development of irrigation facilities in Punjab have resulted in weed flora shifts in wheat fields from *Carthamus oxycantha, Asphodelus tenuifolius* and *Avena ludoviciana* to *Phalaris minor, Rumex dentatus, Medicago denticulata, Rumex spinosus Chenopodium album, Polypogon monspeliensis* and *Malva neglecta*. *P. minor* dominates in rice-wheat while *A ludoviciana* still a dominant grass weed in non rice-wheat cropping areas; *Coronopus didymus* and *Poa annua are* on the increase under high soil moisture conditions. *P. minor* evolved resistance to isoproturon in early 1990s due to continuous use of this herbicide for more than 15 years. Post application of fenoxaprop, clodinafop and sulfosulfuron effectively controlled resistant *P. minor*; which was showing cross resistance to these herbicides with their continuous use for more than 5 years. Combination of cultural practices viz alternate crop rotations, early sowing in narrow rows, high seed rate and quick growing varieties sufficiently reduce the intensity and growth of *P. minor*. Pre-em trifluralin and pendimethalin effectively control resistant *P minor* and some broadleaf weeds; post application of mesosulfuron + iodosulfuron and pinoxaden provide effective control of resistant *P. minor* and *A ludoviciana*. Post application of 2,4-D, metsulfuron and carfentrazone effectively control major broadleaf weeds like *R. dentatus, C. album, M denticulata and C didymus;* metsulfuron control hardy weed *R spinosus* and carfentrazone control *Malva neglecta,* in addition to other broadleaf weeds. Isoproturon and mesosulfuron+iodosulfuron provide effective control of *P. annua, A ludoviciana* and many of broadleaf weeds. In rapeseed and mustards, having similar weed flora to wheat, pre-plant trifluralin and fluchloralin alone or followed by one hoeing are effective. Change in tillage practices due to rice cultivation shifted weed flora from typical summer annual to water loving weeds like *E crusgalli, P. colonum, Paspalum distichon, Alternanthera* sp, *Cyperus iria, C. difformis, Ischaemum rugosum* and semi aquatic and few aquatic weeds such as *Leptochloa chinensis, Ammania baccifera, Caesulia axillaris* and *Sphenochlea zeylanica*. Pre emergence application of butachlor, oxadiargyl, pyrazosulfuron, pendimethalin and post application of bispyribac effectively control annual grasses; post application of metsulfuron, ethoxysulfuron, bensulfuron, azimsulfuron control broadleaf and sedges in transplanted rice.

In other *Kharif* season crops like cotton, maize, sugarcane, greengram, blackgram soybean, turmeric and summer season forages, *D aegyptiacum, T portulacustrum, D arvensis, C rotundus, D ciliaris, Eragrostis* sp., *P. colonum, S halepense , Ipomoea* sp dominates weed flora; *Brachiaria reptans, Acrachne racemose* and *Commelina benghalensis* are replacing above weed sp in maize and sugarcane as they are tolerant to field rates of atrazine. In cotton, sequential application of pre-plant trifluralin/pre-em pendimethalin and protected post application of gramaxone/glyphosate or one to two hoeing is effective. In maize and sugarcane, pre-em atrazine is effective against annual grasses and broadleaves while post application of 2,4-D amine manages *Cyperus* sp and *Ipomoea* sp; pre-em metribuzin/diuron in sugarcane and tank mix application of atrazine with either of trifluralin/alachlor in maize effectively controls annual weeds including hardy grasses like *Brachiara, Acrachne* and *Commelina*. Pre-em application of pendimethalin is recommended in greengram, blackgram and soybean, however, follow up post-application of imazethapyr is required for control of *Cyperus* sp and hardy grasses like *Commelina* sp not controlled by pendimethalin. In turmeric, integrated use of pre-em pendimethalin/metribuzin/atrazine with paddy straw mulch provide long term control of mixed weed flora.

L - 15 Current status of aquatic weeds in India and management strategies

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Weeds growing in aquatic habitat and completing their life cycle in water are called aquatic weeds. They cause harm to aquatic environment directly and to related eco-environment indirectly. India possesses 28% of irrigated areas and has problems of aquatic weeds. Water is one of the most important natural resources required by all life forms of this world. Aquatic weeds multiply very fast and cover the water bodies posing various problems – interfere with the use of water bodies in terms of navigation, fishing, domestic and industrial water supplies, livestock, irrigation, transportation, communication, sports, recreation, tourism, pollute water bodies, block water-intake points and water flow in irrigation channels, affect other useful plants, health related problems to human beings, lowers bio-diversity, etc.

Aquatic weeds are classified as free floating weeds, emergent weeds/ditch bank weeds, rooted weeds with floating leaves, submersed weeds, algae, etc.

Emergent weeds grow in shallow waters, situations existing near to water bodies, swampy areas – banks of canals, rivers, periphery of water bodies of earthen dams or partly masonry dams, drainage ditches and water ponds near villages, etc. They include *Typha angustata, Phragmites communis, Ipomoea carnea, Alternanthera philoxeroides, Ipomoea aquatic, Jussiaea repens*, *Marselia quadrifoliata*, etc. Algae are the most common group of weeds in aquaculture ponds, may be plankton algae (produce dissolved oxygen in the water during sunlight), filamentous algae (pond moss) and stone warts (*Chara* spp and *Nitella* spp). The major floating weeds are *Eichhornia crassipes*, *Salvinia molesta, Pistia stratiotes, Lemna minor, Saggitaria guayanensis, Ipomoea hederacea, Nelumbo nucifera* and *Nymphaea alba.* The major submerged weeds are *Hydrilla verticillata, Potamogeton* spp and *Vallisnaria spiralis.* The aquatic weeds (emergent, floating and submersed) interferes with the static and flow water system in different parts of India.

Therefore, considering the losses caused by aquatic weeds, it is essential to keep aquatic weeds under control in various situations of aquatic systems to save precious water from evapo-transpiration, maintain quality of water and biodiversity, and make best use of water bodies for profitability, efficiency and to improve socio-economic conditions of our country.

Management practices include prevention, physical and mechanical methods, herbicides and biological control. Preventive measures such as proper pond construction and maintenance will help to maintain ponds weed free. Effort should be made to contain the weed completely in the initial stages of introduction in the water course itself by forming water users' association. Use of manual labour for all types of aquatic weeds is effective, costly tedious, many times impracticable. A large number of machines - floating as well operating from the banks are available for mechanical removal of aquatic weeds - emergent weeds particularly cattails and some submerged weeds. The operation is costly and maintenance of machinery exclusively for weed control is difficult, unless government machinery is involved in such maintenance. Weeds cut down or harvested by the machinery have to be removed from the aquatic body to prevent eutrophication process in water bodies. Herbicides are cheaper, effective and rapid control of aquatic weeds (floating, emergent/ditch-bank) in specific situations of water – not meant for drinking, fish production and irrigation. Herbicides affect ecology of aquatic weeds due to direct effect on target and non-target organisms. Biological control – includes triploid white amur – grass carp (consume ten times the quantity of weed biomass of submerged weeds); and host-specific insects - *Neochetina eichhorniae* and *N. bruchi* (*Eichhornia crassipes* good success in some places, limited success in others) and *Cyrtobagus salviniae* (Salvinia molesta – great success in Kerala). There is need to evaluate pathogens to manage these weeds, apart from expanding the biological control to other weeds and making campaign to create awareness among water users for the periodical management by themselves.

L - 16

Major weeds and their management in Uttarakhand

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Uttarakhand represents a unique geographical area where altitude ranges from 200 m to up to more than 2400 m above MSL. The soil, climate and rainfall offer greatly from place to place. The climate varies from sub-tropical to temperate, where the annual rainfall ranges from 1200-2500 mm and temperature varies from less than freezing point in higher hills to more than 40^0C in the plains. The mountain peaks are snow covered during winters while the higher peaks in the cold zones are perpetually under snow.In terms of agro-climatic conditions, the state has got plains of Haridwar, *Tarai* region represented by Udham Singh Nagar and some "*Bhabar*" areas of Nainital, Dehradun and Champawat districts. The remaining part represents the hill region.

In the plains, particularly in the *Tarai* and *Bhabar* region, the climate and highly productive soils favour luxuriant growth of many weed species. During rainy season, annual grasses like *Echinochloa colona*, *E.crus-galli*, *Eleusine indica*, *Brachiaria ramosa*, *Dactyloctenium aegyptium*, *Paspalum distichum, Digitaria* spp. and perennial grasses like *Sorghum halepense*, *Phragmites karka, P. comunis* and *Cynodon dactylon* are the major weeds in crops like maize, soybean, rice, sugarcane, kharif pulses and vegetable crops. Sedges like *Cyperus rotundus*, *C. iria*, *C. difformis*, *Scirpus* spp. and *Fimbristylis milliacea* are very common in the rice fields. Among non-grasses, *Trianthema monogyna*, *Celosia argentea*, *Commelina benghalensis, Commelina diffussa*, *Cleome viscosa*, *Caesulia axillaris, Cynotis axillaris, Eclipta alba, Euphorbia hirta, Lindernia spp., Ludwigia* spp., *Sphenoclea zeylanica, Alternanthera sessilis* are common during rainy season. *Ischaemum rugosum, Eragrostis japonica* and *Leptochloa chinensis* are becoming serious problem in the rice crop. Several species of *Ipomoea* have become serious problem in the sugarcane fields. Density of *Trianthema monogyna* is on continuous increase in almost all upland crops grown during rainy, spring and summer seasons.

During winter season, the major weeds in crop fields are *Phalaris minor, Avena ludoviciana, Chenopodium album*, *Melilotus alba*, *M. indica*, *Medicago denticulata*, *Fumaria parviflora*, *Vicia sativa*, *Anagalis arvensis* and *Lathyrus aphaca*, at some places, *Polypogon monspeliensis*, *Poa annua*, *Lolium temulentum, Cirsium arvense* and *Convolvulus arvensis* are also found infesting *Rabi* crops. Due to continuous use of isoproturon and 2,4-D in wheat, the weeds *Lathyrus aphaca*, *Melilotus indica, Rumex* spp. and *Medicago denticulata*, which are normally not controlled by these herbicides, are increasing. In wastelands and road-sides, the problem of *Parthenium hysterophorus* and *Lantana camera* are very common. In orchards, gardens and lawns, *Imperata cylindrica* has been found to be the most problematic weed.

In hilly regions, *Oxalis latifolia* is the most common and problematic weed in almost all kharif crops. In addition to that *Galinsoga parviflora, Ranunculus arvensis, Fumaria parviflora*, *Vicia sativa, Medicago denticulata, M. indica* are also found infesting the crop lands.

Negligence towards weed management is one of the most important factors responsible for low productivity of crops, as the losses due to weeds ranges from 10- 90% under different agro-climatic conditions of Uttarakhand. The reduction in crop yield due to weeds depends upon crop cultivar, weed species & density, cropping system, plant spacing, fertility and moisture status of the soil, climate as well as environmental conditions. In Uttarakhand, except Udham Singh Nagar, Haridwar and plains of Dehradun and Nainital districts, the crops are mostly grown in rainfed areas where soil moisture and nutrients are the most limiting factors and weeds compete for these major resources very much. Adoption of appropriate weed management options would improve crop productivity in different crops and cropping system of the state.

L - 17 Emerging weed problems and their effects on crop production under changing climatic situation

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Climate change poses several challenges for managing weeds. Climate change means more extreme weather events, greater stresses on native species and ecosystems, and climate-driven activities. When native vegetation is stressed or destroyed by droughts, fires, floods or severe storms, weeds gain new opportunities to replace native species. In particular, climate change could cause dramatic shifts in species' distributions, and species' extinctions, particularly across fragmented or vulnerable ecosystems. Globally, there is a growing list of recent changes in species' distributions, abundances and lifecycles that are highly likely to be due to climate change.

Any change in crop/weed interactions which might result from global climatic change could be important in terms of crop production, economics and sustainability. Changes in temperature, precipitation and increasing [CO_2] all have potentially important consequences for crop/weed interactions, which is evident from a consideration of the basic biology of weeds and crops. Changes in the weed growth and phenology, weed seed bank dynamics, competitiveness, invasive potential etc. are predicted to be influenced by the climate change.

Any direct or indirect impacts from a changing climate will have a significant effect on chemical management. Changes in temperature, wind speed, soil moisture and atmospheric humidity can influence the effectiveness of applications. For example, drought can result in thicker cuticle development or increased leaf pubescence, with subsequent reductions in herbicide entry into the leaf. These same variables can also interfere with crop growth and recovery following pesticide application. There are number of studies that demonstrate a decline in chemical efficacy with rising CO_2.

Biological control of weeds by natural or manipulated means is likely to be affected by increasing atmospheric CO_2 and climatic change. Climate as well as CO_2 could alter the efficacy of weed bio-control agents by potentially altering the development, morphology and reproduction of the target pest. Direct effects of CO_2 would also be related to changes in the ratio of C:N and alterations in the feeding habits and growth rate of herbivores. The, synchrony between development and reproduction of bio-control agents and their selected targets is unlikely to be maintained in periods of rapid climatic change or climatic extremes.

There are invasive plants in waiting to colonise the spaces left bare by drought, fire and storm damage, wind and flooding. In many cases the impacts of invasive species benefiting from climate change are likely to exceed the direct impacts of climate change.

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Major Weeds and their management in Bihar

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Bihar is proved to be a leading state of eastern zone for bringing second green revolution. Among the major factors contributing to the low productivity in the state weed management is identified as most important. Yield losses due to weed is a major constraints which may be minimized through participatory research and extension approach among farmers, extension workers and weed scientist.The losses incurred due to weed in different crops are to the tune of 23 to 37% in rice, 17 to 40% in wheat, 12 to 28% in maize, 16 to 23% in sugarcane, 19 to 45% in *Kharif* pulses, 13 to 33% in *rabi* pulses, and 21 to 38% in mustard. *Oryza rufipogon*, *Echinochloa* sp., *Dactyloctenium aegyptium, Cyperus deformis, Cyperus irria, Cyperus rotundus, Eclipta alba; Caesulia axillaries, Monochoria vaginalis, Echornea crassipes* and *Commelina diffusa* are major weeds in rice field. *Phalaris minor, Cannabis sativa, Avena fatua, Chenopodium album, Cirsium arvense, Melilotus alba, Physalis minima, Melilotus indica, Cyperus rotundus, Cynodon dactylon, Launea pinnatifida* etc. are major weeds of wheat crop. *Avena fatua, Setaria faberii, Phalaris minor, Cyperus rotundus, Physalis minima, Launea pinnatifida, Chenopodium album, Cannabis sativa, Circium arvense,* etc. are major weeds in maize. *Cynodon dactylon, Phalaris minor, Chenopodium album, Cirsium arvense, Convolvulus arvensis. Amaranthus spinosus, Caesulia axillaris, Ipomoea aquatic, Saccharum spontaneum, Solanum nigrum, Physalis minima, Striga* etc. are the major weeds in sugarcane. *Vicia sativa, Xanthium strumarium, Vicia hirsuta, Parthenium hysterophorus, Solanum nigrum, Phaseolus minima, Argemon maxicana, Cirsium arvense, Oxalis corniculata, Melilotus indica, Leucas aspera, Chenopodium album, Cannabis sativa, Lathyrus sativa, Trianthema monogina, Lathyrus aphaca, Cyperus rotundus, Cynodon dactylon etc.* are major weeds of pulses (gram, lentil, pea, green gram, black gram, arhar). *Argemone maxicana, Cirsium arvense, Chenopodium album, Cannabis sativa, Phalaris minor, Avena fatua, Physalis minima, Lathyrus aphaca, Cyperus rotundus, Cynodon dactylon,* are major weeds of mustard. Management of weed in major field crops. Khurpee weeding, harrowing by deshi plough, use of spade in wider row crop are the common practice which have been used by the farmers of Bihar. But now a days all these practice became difficult and costlier due to scarcity of labourer. Some useful mechanical instruments *i.e.,* “hand hoe,wheel-hoe,rotory-hoe,cono-weeder and power weeder are found to be very effective and economical to control weeds of all line sown crops.Using crop geometry like criss-cross sowing of wheat, paired-row planting in sugarcane, double row planting of rice and wheat on bed,and cultivation of wheat, mustard, lentil, chickpea and linseed, by using zero tillage maching are another effective methods for minimizing the weed population and their growth. Use of herbicides are becoming most popular among farmers for controlling weeds in different crops. Pre-emergence application of Pretilachlor 0.5 kg/ha was found most effective to control complete weed flora under transplanted rice. Post emergence application of Bispyribac sodium 30 g/ha was found very effective to control, most of the sedges and grassy weeds of DSR, planted rice as well as in nursery of rice. In case of broad leaved weeds application of 2,4-D, sodium salt 500 g/ha as a POE is found very effective and also enhance the yield of rice. Most of the weeds in the field of wheat is very effectively controlled by using sulphosulphuron 25 g/ha at 28-30 DAS. POE application of 2, 4-D sodium salt or Amino salt 500-600 g/ha is effective to control all broad leaved weeds in wheat crop except *Physalis minima*. PE application of metribuzine 500 g/ha is effectively used for controlling weeds in most remunerative cropping system of Bihar i.e. maize + potato. PE application of atrazine 1.5-2.0 kg/ha + POE application of 2,4-D, Sodium salt/amino salt *fb* earthing up at 80 DAS are able to control all types of weeds in sugarcane. PE application of pendimethaline 1 kg/ha effectively control weeds in the field of most of pulses crops *i.e.,* chickpea, pea, lentil, green gram and black gram. POE application Imazethpyr 50 g/ha is found effective for suppresing of weeds in the field of pigeon pea and soybean. PE application of isoproturon 1000 g/ha is effectively control all type of weeds in the field of mustard crop. PE application of Oxadiazon 800 g/ha is effectively control all type of weeds in the field of sunflower.

L - 19 Weed management in zero tillage in India : current scenario and prospectus

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The green revolution boosted the productivity of rice–wheat systems through the introduction of high-yielding varieties and complementary technologies like irrigation and fertilizer in a supportive policy environment. Recent studies however indicate a slowdown in productivity. Zero tillage farming (also called No-till or direct planting or pasture cropping) is a way of growing crops from year to year without disturbing the soil through tillage. No-till is an agricultural technique which increases the amount of water and organic matter (nutrients) in the soil and decreases erosion. The residues from the previous crops will remain largely undisturbed at the soil surface as mulch. It increases the amount and variety of life in and on the soil but may require herbicide usage. The invention of the herbicide Paraquat in 1955 in the United Kingdom was the start of modern no- tillage development in Europe and also world-wide.

Recent studies indicate a slow down in the productivity of growth in the rice-wheat system in India, delayed sowing and weeds are the main constraint out of others. In general, season long competition from major weeds culminates in yield reduction. In this context, one of the most serious incidences is the one associated with isoproturon-resistant grass, *Phalaris minor*. Application of paraquat (two days before sowing) + isoproturon+2, 4-D and two hand weeding resulted highest weed control efficiency and net profit. At GBPUAT, Pantnagar higher weed density and population of *Phalaris minor* in conventional tillage was recorded than zero tillage. Pre-sowing paraquat application had marked effect on weed growth in zero tillage. Maximum reduction in weed density was obtained with the application of 2,4–D and isoproturon as mixture under ZT and CT system. Higher average grain yield was achieved under zero tillage wheat with pre-sowing paraquat (500 g/ha) application and post-emergence isoproturon (1000 g/ha) or mixed application of 2, 4–D and Isoproturon (500 g+ I000 g/ha). Yield achieved in zero tillage without any herbicide application was comparable to conventional tillage with application of Isoproturon.

High input use without any significant yield gains and without compensating in the form of increased price of wheat have drained farmers of cash and squeezed them into financial difficulties. Zero tillage, therefore, can help farmers to pay for new herbicides. The demand for zero tillage is driven not only because it assists in better weed control but also it will replace the lengthy procedure of wheat sowing. The success of zero tillage technology will greatly improve the chances of increasing cropping intensity.

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Major weeds of Karnataka and their management

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Karnataka state has diverse agro-ecological regions comprising different crops and cropping systems in ten characterized agro-climatic zones with a vast stretch from dry lands to coastal lands. Accordingly, the diversity in weed flora is also seen across the state. In the present day Karnataka agriculture, weeds are posing a major threat to crop production and productivity. Now farmers have realized that weeds are the major pests compared to insects and pathogens. There has been a great shift in the weed management practices adopted by farmers in view of labour scarcity as well as increased costs. In addition to this, moisture budget in the soil is a deciding factor for increasing the crop productivity. In the present uncertainty of changing climate with special reference to rainfall, it is inevitable to conserve water and nutrients in soil for use by crops and cropping systems by effective control of weeds during the critical growth period of crops.

The existing popular cropping systems in Karnataka are - pigeonpea based system with greengram, blackgram, sesamum, sorghum as intercrops in NE transition zone (zone-1). Frequent intercultivation in these systems becomes difficult and the farmers have to depend on chemical weed management. While in North Eastern Dry Zone (zone-2), sole pigeonpea dominates the scene. Northern Dry Zone (zone-3) has majorly maize, sugarcane, paddy and *Rabi* sorghum. In Central Dry Zone (zone-4) groundnut and horsegram, coconut – based cropping system are prominent. In Eastern Dry Zone (zone-5), pulses, finger millet, forage crops, mulberry, sunflower, horticultural crops are the major crops., Southern Dry Zone (zone-6) has sugarcane, rice, ragi and maize, hybrid rice, horticulture; In Southern Transition Zone (zone- 7) tobacco, rice (canal irrigated, tankfed, drill sown) and rainfed cotton, banana and irrigated cropping systems. In Northern Transition (zone-8), the dominant crops are cotton, maize, soybean, sugarcane, chickpea, rabi sorghum, wheat. In Hilly Zone (zone-9) paddy cardamom, pepper, arecanut, multiple cropping systems in plantation crops, vegetables, floriculture, rice-based cropping systems, chilli are important. Coastal Zone (zone-10) has paddy-based cropping systems and horticulture. These zones have a wider diversity of weed flora owing to their specificity in a given cropping situation.

The community of dominant weed flora across different agro-climatic zones are *Parthenium hysterophorus*, *Alternanthera sessilis*, *Trianthema portulacastrum, Digera arvensis, Portulaca oleracea, Commelina benghalensis, Cyanotis* spp*, Digitaria sanguinalis, Dinebra retroflexa*, *Panicum isachne*, *Eleusine indica*, *Celosia argentea* among annuals and *Cynodon dactylon, Cyperus rotundus* among perennials. Farmers have been adopting management strategies to control these weeds.

This paper addresses these issues in general, and in relation to trials and extensive surveys conducted in farmers' fields in all the agro-climatic zones, success stories of farmers in the jurisdiction of UAS Dharwad with additional support drawn from other ecosystems wherever prime examples are available. In the past, the attention was paid towards single weed management strategy, while the current strategy focuses on integrated approach due to availability of a wide range of eco-friendly herbicide molecules. This paper emphasizes the viable weed management strategies in these crops in general for the benefit of farmers.

L - 21 Parasitic weeds problem and their management in India

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Parasitic weeds are becoming major constraints to many crops in tropical agriculture and the efficacy of available means to control them is minimal. True plant parasites can be hemi-parasitic (semi-parasitic) with photosynthetic leaves (such as witch weed and loranthus), or holo-parasitic and completely dependent on their host (such as dodder and broomrape). It is apparent from the reviews that parasitic weeds often have a significant detrimental effect on their hosts due to direct removal of resources from them. Unlike other weeds, parasitic weeds remove nutrients and extract water from the host plant causing heavy losses to agricultural crops. The adverse effect of these parasitic weeds has been so devastating; the crop yield losses of 10 to 100 per cent have been recorded, which leads to complete crop failure and sometimes abandonment of land.

In India, dodder (*Cuscuta* spp.) poses a serious problem in oilseeds (niger, linseed) and pulses (blackgram, greengram and lentil especially in rice-fallows) and fodder crops (lucerne, berseem) in the states of Andhra Pradesh, Chhattisgarh, Gujarat, Orissa, West Bengal and parts of Madhya Pradesh under rainfed as well as in irrigated conditions. Of the 12 species reported from India, *C. campestris* is the most common. Dodder infestations can weaken the host plant, making it susceptible to other pests and diseases, and may eventually kill its host. Witch weed (*Striga* spp.) is a major weedy pests throughout semi-arid sub-Saharan Africa and parts of Asia on crops like sorghum, sugarcane, maize, pearl millet, dry land rice etc. Resource-poor, small-scale, subsistence farmers are severely affected with *Striga* infestation. Of the 4 important *Striga* species in Asia, *Striga asiatica* (*S. lutea*) is common in India. Broomrape (*Orobanche* spp.) parasitizes various dicotyledonous host plants of family fabaceae, solanaceae, Asteraceae, etc. In India, *O. cernua* and *O. aegyptiaca* are major parasite in tobacco in parts of Karnataka, Andhra Pradesh, Tamil Nadu, Gujarat, mustard in Rajasthan, Haryana, parts of Gujarat, Madhya Pradesh (MP), and Uttar Pradesh, and in vegetables such as brinjal, tomato, potato, etc. and causing significant damage. *Loranthus* is a common parasite on subtropical trees. The plant bears beautiful orange or scarlet flowers in dense, one-sided up curved axillary clusters. In India a wide range of species occur, of which *Dendrophthoe falcata* is perhaps the more common, damaging many fruit, ornamental and forest tree species. The weed occurs on the terminal growing point resulting in stunted growth of the tree, which affects timber value considerably.

The management strategies have largely focused on agronomic practices, the use of resistant/tolerant cultivars and the use of herbicides with marginal success. There is, thus, an urgent need to re-evaluate the control methods in the light of recent developments in herbicide molecules, crop breeding and molecular genetics and to place these within a framework that is compatible with current agronomic practices. Emphasis should be given to understand the interaction between parasitic plants and their hosts in order to implement sustainable means of control. Interdisciplinary research is required to develop effective integrated management strategy for parasitic weeds.

L - 22 Major weeds and their management in Himachal Pradesh

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Agriculture is the main occupation of the people in the state. It provides employment to more than 76 per cent of the total population. Due to fragmented and small landholdings, the small and marginal farmers predominate in the peasantry sector. Most of the farmers still practicing subsistence farming where he tries to produce everything he needs. The cereals like wheat, maize, rice and barley occupy the major proportion of cultivated land. Maize in *kharif* and wheat in *rabi* are the two important crops in the state. The other important crops of the state include pulses (mash, Rajmash, gram, peas, lentil, kulth, cowpea), oil-seeds (sesame, brassicas, linseed), potato and sugarcane. Cultivated fodder crops do not occupy sizeable area and the state depends on natural grasslands and grazing lands for meeting the fodder requirement. Weeds have been considered enemies of the farmers from the dawn of agriculture. Depending upon their diversity and intensity they cause severe losses in the productivity of field, orchard, vegetable crops and grasslands. Weed problems vary from crop to crop, farm to farm and from region to region and the weed spectrum also varies with the soil types and agro-climatic conditions. *Echinochloa colonum*, *E. crusgalli*, *Setaria glauca, Cyperus* spp. *Digitaria sanguinalis* and *Eleusine indica* grow extensively during *kharif* throughout the state, excepting high hills and dry Zone. Among broad-leaved weeds *Polygonum* sp. and *Ageratum conyzoides* dominate in warm mountaneous regions of Kangra, Mandi, Una, Hamirpur, Sirmour, Solan and Bilaspur districts. *Commelina benghalensis, Brachiaria ramosa* and *Gallinsoga parviflora* have been found dominating in low and mid-hill areas of the state. *Digitaria sanguinalis* and *Amaranthus viridis* predominate specifically in low hills. *Echinochloa* sp., *Cyperus* sp., *Panicum dichotomiflorum* and *Eleusine indica* cause severe infestation in rice fields in low lands as well as uplands.

The important weeds of high hills temperate zone and cold temperate zone are *Amaranthus* spp., *Chenopodium* sp., *Malva* sp., *Conyza stricta, Portulaca oleracea, Digitaria sanguinalis* and *Equisetum typhoides. Medicago denticulata, Ranunculus arvensis, Stellaria media, Anagallis arvensis, Melilotus alba, Silene conidia, Coronopus didymus, Lathyrus aphaca, Euphorbia thymifolia, Vicia hirsuta* and *Vicia sativa* are the major broad-leaved weeds which grow in abundance during winter *(Rabi)* season almost in all parts of the state. These weeds severely infest wheat, barley, gram, lentil, sarson and linseed crops. Grassy weeds like *Phalaris minor*, *Avena ludoviciana, Poa annua* and *Lolium temulentum* are found in *Rabi* crops, however, their incidence is more where preceding crop in *Kharif* is rice. Besides, *Polypogon monsplensis, Alopecurus myosuriodes* and *Poa annua* are also found in *Rabi* crops of the state. Infestation of *Asphodelus tenuifolius, Chenopodium album* and *Fumaria parviflora* in *Rabi* crops is mainly confined to low hill sub-tropical zone. *Portulaca oleracea, Oxalis latifolia, Poa annua, Gnaphalium luteo-album* and *Gallinsoga parviflora* are the important weeds associated with vegetable crops. *Lantana camara, Parthenium hysterophorus, Chromolaena* sp., *Ageratum houstonianum, Saccharum* sp., *Bidens pilosa, Conyza stricta, Rubus* sp., *Bidens pilosa, Conyza stricta, Zizyphus rotundifolia, Erigeron Canadensis* and *Imperata cylindrical* are some of the important weeds of non-cropped areas, pastures and range lands in the state. *Oxalis* sp has low occurrence in crop fields but it is severe in orchards of low and mid-hills. *Paspalam dilatatum* and *Imperata cylindrical* also cause severe infestation in grasslands and pastures. *Ageratum* sp, *Imperata cylindrical* and *Saccharum spontaneum* are the dominant weeds in orchards almost all over the state. Other perennial weeds, *viz., Cynodon dactylon, Sorghum halepense,* are also found in orchards in different agro-climatic zones of the state. In tea orchards, which are confined to about 2000 hectares area in district Kangra and Mandi, the important weeds that pose serious problems for the growth and development of tea bushes are *Imperata cylindrica, Ageratum* spp, *Chromolaena adenophorum, Conyza stricta, Erigeron canadensis* and *Lantana camara.*

L - 23 Herbicide residue in soil, water and commodities : Indian scenario

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Over the years herbicides have emerged as an important tool in the management of weeds. Herbicides represent a large chemistry with different modes of action to control variety of weeds. Due to intensive research in herbicide discovery and mode of action, many new molecules are available at g/ha level to cater the farmers need. In India, the herbicides market has grown many folds in the last two decades. Under excessive and repeated use herbicides may pose problems such as phytotoxicity to crop plants, residues in soil and crop produce, residual effects on susceptible inter-crops, succeeding crops, non-targeted organisms, health hazards due to accumulation of residues and ultimately ground water contamination through runoff and leaching. Thus data on residual toxicity of herbicides become indispensable for approving a herbicide for large scale commercial use, environment safety and human health.

The fate and behaviours of herbicides in soil is influenced by the biotic and abiotic process including adsorption, movement/leaching, decomposition etc. In general the residue problem of most of the herbicides is low, however risk of persistence of herbicides and their secondary metabolites in soil, crop produce and water, if any, can not be over looked. Most of the herbicides, specially more recently developed synthetic herbicides are quite selective for specific weeds and have low mammalian toxicity, however few less selective herbicides of the chlorates and dinitrophenols are more toxic to animals. Now herbicides residue analysis is also become an essential part of chemical weed control to provide meaningful residue data to see risk of contamination, if any by these chemicals under laboratory and field conditions. Sophisticated instruments and advance extraction technologies are being used to extract and identify parent or secondary metabolites in environmental samples.

The recognized persistence of several sulfonylureas, substituted ureas, uracil, s-triazines, the benzoic acid derivatives, picloram and other herbicides in soils has received detailed study in India and abroad. It is being recognized that some persistence is necessary property of all herbicides; with no persistence soil applied herbicide would not control weeds. Though sulfonylureas have less persistence in soil but few member of this class and their secondary metabolites were reported to persist longer in soil and affected succeeding crops. Other classes of herbicides which showed moderate to longer persistence in soil are imidazoline, dinitroanilines and triazines. Leaching of herbicides under lab and field conditions is well documented. Pretilachlor, codinafop-propargyl, metribuzin, atrazine etc were reported upto 40-90 cm depth under lab conditions in sandy loam and loamy sand soils, however triabenuron, and oxyfluorfen were reported to move more than 1-metre in soil profile under continuous rain in sandy loam soils. Dinitroanilines and imidazolines were found less mobile in sandy clay and loamy sand soils. In well water herbicide concentration of 2,4-D, atrazine , paraquat, diquat etc were reported between 0.5 to 800 μg/L. residues of most common used herbicides viz. butachlor, sulfosulfuron, imezathapyr, oxyfluorfen, isoproturon, fenoxaprop etc were found below MRL values. It has been found that under tropical, subtropical and high rainfall conditions herbicides rapidly degrade by chemical and biological process, and hence residues are generally not detected above the safe level at harvest in crop produce and soil and hence contamination due to herbicide can be considered as less.

L - 24 Major weeds and their management in Jammu & Kashmir

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Jammu & Kashmir is India's northernmost state, lying between six mountain ranges and covering an area of 2,22,236 sq. kilometers. It is located between 32°17' and 36°58' North latitude, and between 37°26' and 80°30' East longitude. Weeds pose some of the serious threats to biological diversity. Among the various weed species some are of very offensive nature whether native or of exotic origin that erode the native biodiversity. Major weed species found in in J&K particularly are : **Cultivated fields**: Lowland rice- *Eichnochloa colonum/ crusgalli ;Fibristylis miliacea ;Ammania baccifera ;Cyperus iria/rotundus; Marsillia quadrifolia ;Potamogeton distinctus ;Salvinia auriculata;Lemma minor;* Upland crops- *Papaver dubium, Renunculus arvensis, Lolium temulentum, Bromus japonicas, Poa pratensis, Cynodon dactylon, Vulpia myuros, Polygonum tubulosum, Convolvulus arvensis* and *Galium aparine*.; *Trianthema monogyna; Portulaca oleracea; Ipomoea carnea/hispida ;Elusine indica ; Panicum repens; Sorghum halepense/nitidum ; Poa annua ;Setaria glauca; Amaranthus hybridus/graecizans; Euphorbia hirta/emodi;* **Tourist spots, fruit orchards and grass fields:** *Robus, Rosa, Rubia, Hedera* and *Spiraea Oxalis corniculatus, Tribulus terrestris ;Erodium cicutarium, Gallium aparine, Bellis perennis, Stellaria media, Anagallis arvensis, Eruca sativa, Convolvulus arvensis, Poa annua/pratensis, Bromus japonicus, Eragrostis spp. ; Malva rotundifolia; Setaria viridis* and *Phleum paniculatum.* During summer months *Lotus corniculatus, Melilotus alba;* species of *Trifolium, Lathyrus, Medicago, Sisymbrium, Erigeron, Astragalus; Geranium ocellatum/ pratense;Calamintha clinopodium; Nepeta cataria; Fragaria vesca; Thymus serpyllum; Rumex nepalensis* and *Taraxacum officinale* predominate these land pockets. **Waste lands**: *Ranunculus arvensis/ falcatum, Conium maculatum, Silene conoidea, Capsella bursapastoris, Cynoglossum denticulatum, Goldbachia laevigata, Polygonum tubulosum* and *Anagallis arvensis. Verbascum Thapsus, Cichorium intybus, Euphorbia helioscopia/thymifolia, Xanthium strumarium, Sisymbrium loeselii/Sophia, Bupleurum lanceolatum, Galinsoga parviflora, Utrica dioica, Marrubium vulgare, Cousinia microcarpa, Centaurea iberica, Digitaria marginata, Setaria verticillata* and *Eragrostis nigra, Cronopus didymus, Ttribulus terrestris* and species of *Oxalis, Herniaria, Geranium* and *Veronica.* **Water bodies:** Submerged weeds in lakes are *Potamogeton lucens/pectinatus/crispus, Hydrilla verticillata, Myriophyllum spicatum, Ceratophyllum demursum* and *Chara spp.* Free floating water ferns are *Salvinia natans* and *Lemna spp.* Towards the water margins a free floating herb *Nymphoides peltatum* with small lotus like leaves is predominant. Besides the side projections and shallow portions are full of tall reeds and cat-tails like that of *Phragmites cummunis* and *Typha angustata.* Some of the herbicidal management measures practised in the state are: **Rice:** *Chemical methods:* 1) Butachlor granules 5 G 30 kg/ha at 4-6 days after transplanting in standing water 2-3 cm deep and do not drain the field for one week. 2) anilophos + ethoxy sulfuron 0.375+0.015 kg/ha at 10 DAT. 3). 3 lt of butachlor 50 EC in 150 kg sand and broad cast in standing water within 2 DAT. **Maize:** *Chemical methods:* 1) Atrazine 1.0 kg/ha in 800-1000 liters of water should be soil applied just after sowing in sole maize crop; 2) For maize+pulse mixed cropping, apply pre-emergence pendimethalin 1.0 kg/ha or pre-plant incorporated fluchloralin0.75 kg/ha. Wheat: for broad spectrum weed control isoproturon0.75 kg + 2,4-D ethyl ester500 ml/ha may be sprayed with 500-600 lts of water at 30-35 days after sowing; 2) Metribuzin 200-250 g/ha should be sprayed at 30-35 DAS where isoproturon is not able to control *sitti*. **Rapeseed and Mustard:** Fluchloralin 0.70 kg\ha ppi, isoproturon 1.0 kg\ha pre-em, , pendimethalin 1.0 kg\ha pre-em. **Marigold:** 2 hand weedings at 20 and 40 days after transplanting or application of trifluralin 1.0 kg/ha pre plant incorporation (PPI)+1HW (46.2q/ha). Gladiolus: 2 hand weedings at 20 and 40 days after transplanting or application of pendimethalin 2 kg/ha +1HW. **Okra:** Fluchlorian 1.0 kg/ha PPI, alachlor 2.0 kg/ha pre emergence application (PRE), trifluralin 1.0 kg/ha PPI and oxyflorafen 0.35 kg/ha PRE along with 1-hand weeding.

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Weed management in organic farming:challenges and prospects in India

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Organic farming is being practiced in more than 120 countries of the world. An estimated area of 0.65% of the total agricultural land is grown organically world over. It is gaining momentum in India owing to the concerns expressed on the safety of environment, soil, water and food chain. It is estimated that only about 0.3% of the total cultivated area in India is under organic farming, mostly in the states like Madhya Pradesh, Odisha, Maharashtra, Jammu & Kashmir, Rajasthan, Karnataka, West Bengal and Gujarat. Cultivating crops organically, and at the same time maintaining higher production levels is a big challenge. Since organic farming is different than natural farming, availability of organic resources for soil cultivation, manuring, plant protection etc. are also a limiting factor.

Herbicides, for weed management are seen as a better alternative in areas of labour scarcity. However, over-reliance on herbicides may lead to development of herbicide resistant weeds as seen in the case of isoproturon resistant *P. minor* in the Indo-gangetic plains. In any organic agriculture system, adopting cost effective weed management practices is a major issue for achieving sustainable production levels. Weed management in organic agriculture should simulate the principles of biological processes for desired suppression of weeds. Preventive weed management practices, higher plant population, manipulating crop geometry, stale-bed technique, competitive crop varieties, intercrops and cover crops, crop rotation can be followed in an integrated manner where ever feasible. Weeding through non-chemical means have to be undertaken within the critical period of the crop. More dependence on the use of efficient mechanical weeding tools is also advocated in organic agriculture.

Effective training and education mechanism needs to be developed for utilizing the multiple tactics of weed management in organic agriculture. Since organic produce sells at a premium price, the farmers, particularly in tribal areas may be educated for scientific weed management to be adopted under organic agriculture for higher income and upliftment of their socio-economic status.

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Major weeds in field crops of Chhattisgarh and their management

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The Chhattisgarh with an average rainfall of 1250 mm, of which 85% occurs during June to September is mainly a rice growing and consuming area. During *kharif*, rice occupies an area of 3.52 m ha i.e. nearly 75% of the total cultivated area followed by urd (1.83 m ha), maize (1.71 m ha), pigeonpea (1.41 m ha), soybean (1.33 m ha) and miner millets, moong, groundnut, sesame, niger, vegetable *etc.* in rest of the area. While during *rabi* season, an area of 1.52 m ha is under different crops like lathyrus (0.35 m ha), chickpea (0.32 m ha), wheat (0.18 m ha), mustard (0.16 m ha) and rice, maize, field pea, lentil, moong, urd, linseed, safflower, sunflower, groundnut, sugarcane, vegetable etc. in rest of the area. During *kharif* season, major weed flora consists *of Echinochloa* spp., *Ischeamum rugosum, Dinebra retroflexa, Brachiaria ramosa* among grasses*, Cyperus iria, Cyperus difformis, Cyperus rotundus, Fimbrisyllis miliacea* among sedges and *Caesulia axillaries, Commelina benghalensis(monocot), Monochoria vegenalis, Eclipta alba, Alternanthera triandra etc.* among broad leaved under mid-lowland ecosystem, while under upland situations; *Echinochloa* spp*, Brachiaria ramosa, Dinebra retroflexa, Sporobolus diander* among grasses*, Cyperus iria, Cyperus difformis, Cyperus rotundus* among sedges and *Euphorbia geneculata, Alternanthera triandra, celocia argentia, Eclipta alba, Corchorus octavalia, Ludvigia parviflora etc.* among broad leaf weeds. Whereas, during *rabi* season, *Echinochloa colona, Brachiaria retroflexa, Cynodon dactylon etc.* among grasses and *Chenopodium album, Medicago denticulata, Melilotus alba, Alternanthera triandra, Rumex dentatus, Anagalis arvensis, Spilanthes acmella etc.* among broad leaf are the pre-dominant weeds of the region.

Up-till 2005, manual weeding was the main method of weed management in the state with a very meager area of 0.13 m ha through integration of herbicide plus manual weeding. Butachlor, pretilachlor, anilophos, Pendimethalin, trifluchloralin, atrazin and 2,4-D were the only herbicides in use for weed control in different crops. Moreover, rice, soybean and wheat were the only crops where these herbicides were generally used as pre and post emergence. The reasons behind this was (1) ample availability of agricultural labourers at a very cheap wages (2) Wider range of post-emergence herbicides was not available as is available today especially for rice, soybean, wheat *etc.* (3) Least technical know-how towards herbicide technology. However, 2005 onwards, speedy increase in urbanization, industrialization, education, employment opportunities in the state sharply reduced the availability of agricultural labourers at peak periods of agricultural activities as well as their increased wages forced the farming community to look for an effective, labour-less and economical alternative over existing manual weeding method. Fortunately, the need of farmers and time of launch of very effective post-emergence herbicides in the recent past coincided and have given an alternative of labour depended weeding in field crops. Presently, post-emergence application of new molecules like fenoxaprop-p-ethyl for the control of grasses in paddy, wheat, mustard, soybean *etc.,* Chlorimuron+metsulfuron, pyrazosulfuron, ethoxysulfuron for broad-leaved in paddy, bispyribac Na for mixed weed flora of rice, metsulfuron, sulfosulfuron, in wheat, Imazethapyr for mixed weed flora of soybean, moong, urd, groundnut etc. have attracted the farmers towards herbicide technology. This has resulted in a growth of 82 per in last 6-7 years as well as area under these herbicides has crossed 0.70 m hectares with a minimum monetary saving of Rs. 140.0 million by not employing costly manual labor for weeding only.

L - 27 Weed shift in long term cropping system

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Adoption of a single method of weed management over a long period of time may cause weed shift especially when the given weed management practices do not control all kinds of weeds. In view of this, long term impact of various weed management strategies in crops and cropping systems has been reviewed. Tillage and cultivation are the traditional means of weed management in agriculture. Tillage depth and kind of implements used affects the establishment of weed flora in field. These factors considerably influence weed seed and propagule distribution over the soil profile and therefore they directly affect the number of weeds that can emerge in a field. Crop rotation is an effective weed management tool which prevents the proliferation of a particular kind of weed species.

Weed species vary in their response to fallow situation which is often included in many crop rotations to conserve moisture. Several factors may contribute to unfavourable shift in weed flora composition due to changes in cropping systems. Weed seed bank density and species composition is often get altered due to changes in cropping strategies. Although herbicides offer a better option to mechanical weeding, their indiscriminate use lead to concerns like weed shift, toxicity and residue problem, and adverse effect on soil micro-organisms. Extreme narrow biological spectrum of the modern herbicides may contribute to significant changes in the agro-ecosystems. Climate change with global warming and increasing atmospheric carbon di-oxide are likely to influence the weed dynamics in different ecosystems. The growing menace from alien weeds is likely to intensify under such changes and in the context of increasing trade, globalization and liberalized economy.

An integrated approach comprising two or more tools or strategies has to be evolved for an efficient weed management system so that any kind of weed shift does not occur. Literature shows that use of IWM system approach has to be preferred as it considers all appropriate tools for effective weed management and prevention of weed flora shift. Some of the integrated approaches have been found to prevent weed flora shift on a long-term basis, whereas probably due to the effect of climate change and some other edaphic factors IWM favoured weed shift in few locations.

L - 28 Major weed problems and their management in Madhya Pradesh with special reference to Gird zone

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In this review an attempt has been made to put forth the important research work carried out on weed management in Madhya Pradesh with special reference to Gird Zone during 25 years (1985-2010) of research. Survey of the weed in difficult crops and cropping systems in districts of Madhya Pradesh, testing of herbicides in different crops, crop weed competition yield loss studies methods of weed management and their recommendation has been covered in this article.

L - 29 Major weeds and their management in Andhra Pradesh

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Andhra Pradesh is the fifth largest state in India accounting for 9 and 8 per cent of the countrys area and population, respectively. The state has three major river basins (Krishna, Godhavari and Pennar) that drains in to the Bay of Bengal and has 972 km long coastal line along its eastern border. Rice is the principal food crops cultivated throughout the state under irrigated ecosystem. In rainfed ecosystem groundnut, castor, pulses and cotton are the major crops. In peri urban areas vegetable cultivation is more fetching. Though there are many factors that contribute to yield reduction, maximum yield loss of 40-45% is caused by weeds only. The lowland ecosystem with rice was infested by terrestrial, semi aquatic or aquatic plants, the major weeds of rice ecosystem in A.P. were *Echinochloa colona, Echinochloa crusgalli* among grasses, *Cyperus difformis, Cyperus iria* among sedges, *Marselia quadrifoliata, Rotala densiflora, Eclipta alba, Monochoria vazinalis* and *Ammania baccifera* among broad leaves. In dry lands that constituted 65% of the cultivated area in A.P., diverse weed flora was reported. Predominant weeds are *Cyperus rotundus, Cynodon dactylon, Dinebra arabica, Rottoboelia exaltata, Celosia argentia, Commelina benghalensis, Euphorbia hirta, Digera arvensis, Legasca mollis,and Allamania nodiflora, Boerhaevia diffusa* were predominant weeds. Broad leaved weeds contributed major weed flora (81%) followed by grasses (7.9%) and sedges (7.9%). In orchards also, of the total weed flora, broadleaved weeds were dominant (66%) followed by grasses and sedges. Major weeds of rice can be managed by pre emergence application of butachlor (1.0 kg/ha) or benthiocarb (1.0 kg/ha) or anilophos 0.4 kg/ha or pretlachlor + safener (0.5kg/ha) or pyrazosulfuron ethyl 25g/ha oxadiargyl (60g/ha) along with one hand weeding at 40 DAP. Several other herbicides like bensulfuron methyl + pretilachlor (6.0GR) 10.0kg product /ha, metsulfuron methyl+ chlorimuron ethyl (4g/ha), bispyribac sodium (25g/ha), cyhalofop-p-butyl(100g/ha), fenoxaprop-p—ethyl (60g/ha), ethoxysulfuron, 2,4-D sodium salt are being recommended for selective weed control in Andhra Pradesh. In crops like maize, sorghum and pearlmillet, preemergence application of atrazine 0.5-1.0 kg/ha with one hand weeding or intercultivation at 35-40 was effective. In cotton, preemergence application of pendimethalin 1.0 kg/ha or alachlor 1.25 kg/ha followed by hand weeding or intercultivation or post emergence of pyrithiobac sodium + quizalofop ethyl 50 g/ha was very effective for weed management. In major pulse crops of Andhra Pradesh, preemergence application of pendimethalin 1.0 kg/ha or alachlor 1.25 kg/ha with one hand weeding or early post emergence application of imazethapyr 75g/ha gave efficient weed control. In rice fallow pulses where grasses were predominant, Fenoxaprop-p-ethyl 60 g/ha was effective for control of grasses especially *Echinochloa crusgalli*

In oilseed crops like groundnut, castor, sunflower, sesame and safflower pre emergence applicatioin of herbicides *viz.* pendimethalin 1.0 kg/ha pr oxyflourfen 0.2 kg/ha or alachlor 1.25 kg/ha supplemented with one manual weeding or intercultiation or post emergence application of quizalofop- p-ethyl 50 g/ha was proved to be the best weed control method. In vegetable crops, pre emergence application of pendimethalin 0.75 kg/ha or alachlor 1.0 kg/ha fb one hand weeding or post emergence application of quizalofop ethyl 50g/ha was found effective and vaiable weed control option. In sugarcane, pre emergence application of 2,4-D 1.0 kg/ha at 45-50 DAP gave efficient weed control.

Among the parasitic weeds, C*uscuta* infestation in pulses especially in rice fallows and lucerne, *Orobanche* spp. in tobacco, tomato, brinjal and carrot. Striga infestation in sugarcane are important. For excellent control of *Cyperus rotundus*, post emergence application 1.5 kg/ha +0.2% ammonium sulphate on three weeks old *Cyperus rotundus* was recommended in non-cropped areas. Removal of Parthenium before flowering reduced soil seed bank. Preemergence application of pendimethalin 1.0 kg/ha or early post emergence application of imazethapyr 75 g/ha effectively controlled Cuscuta menace. Management of Orobanche in solanaceous vegetables through application of imazethapyr and metribuzin have not been encouraging, Cuurently research on soil solarization is in progress. Research on striga infestation in sugarcane is also under progress.

L - 30 Concept and procedure of importing bio agents for biological control of weeds in India

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India is one of the 12-mega diverse countries of the world. With only 2.5% of the land area, India accounts for 7.8% of the global recorded species. This rich biodiversity is threatened by the invasive pests. Alien weed species or alien invasive species are aggressive invaders outside their natural range and they directly affect resource management schemes, such as land use, watersheds and native biodiversity. These have been recognized as the second largest threat to biological diversity and other natural resources after habitat destruction due to manmade causes. Managing such invasive species can be ideally attempted through Classical Biological Control (CBC) by introducing effective co-evolved natural enemies from the home range of the given species in order to re-establish the lost balance between the weed pests and the natural enemies. Several successful attempts have been made to overcome these dreaded invasive weeds and insects. The first recorded success in biological control of a weed was obtained in India, where a bug *Dactylopius ceylonicus* introduced for production of cochineal dye, spread on *Opuntia vulgaris* in central and northern parts of the country and completely eliminated it. The first deliberate attempt was made only in 1921 against *Lantana camara*. Although several well known alien weeds occur in India, only a few sporadic biological control attempts were made until 1980. After the success achieved against *Opuntia* spp., releases of exotic natural enemies were made against *Eichhornia crassipes*, *Lantana camara, Chromolaena odorata*, *Mikania micrantha*, *Parthenium hysterophorus* and *Salvinia molesta*. The recent spectacular successes on CBC of Papaya mealybug *Paracoccus marginatus* and the eucalyptus gall fly *Leptocybe invasa* was overwhelmingly appreciated across the country. Presently, we are facing a challenge to combat and manage several of the quarantine weeds waiting to enter our country to save our biodiversity from already entered weed like giant mimosa (*Mimosa diplotricha*). Although several introduction of natural enemies of weeds have been done in the country for Classical Biological Control, there exists a need to understand the procedural formalities to be followed in exploration, importation, quarantine studies and host specificity studies. The paper attempts to clarify several of these doubts.

L - 31

Weeds as potential source of genetic material for crop improvement : future prospects

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Weeds are reservoir of naturally available gene pool and can be used as a source of genetic material for traits like competitiveness, abiotic and biotic stress tolerance in crop plants. Weedy ancestors of food crops can cope far better with climatic changes than their domesticated counterparts. Coping with adverse conditions, after all, is what weeds have always done best. We have already set in motion far-reaching and unstoppable changes in regional temperatures and precipitation and in the composition of our atmosphere and despite of actions we take, these changes will continue 'at least' for decades. If we have to avoid disaster due to these unavoidable climate changes, experts agree that we need to be tenacious but flexible, ready to identify and exploit any opportunity. In this new world that we have made in search of fast track run for development, weeds, our old adversaries, can be not only tools but mentors to solve the crisis due to climate changes. Weed species which grows along with crop plants act as a dampener for crop production despite of enormous efforts made by farmers for removal of the weeds to get better yield.

Weeds are 'strategically' stronger than crop plants and can dominate crops in almost every aspect. Scientific basis of weedy and invasive traits of weed species along with their evolution is poorly understood, yet, strategy behind this is to utilize soil resources more efficiently than crop plants to achieve a fast and vigorous growth which results in greater biomass and once they successful in doing so, then they can easily capture the other resources like space and photosynthetically active radiation; thus provide a tough competition to the crop plants. Development and availability of the sophisticated molecular tools provide us liberty to play with different metabolic pathways at molecular level and to transfer the desirable genetic materials into crop plants, thus breaking the reproductive barriers for inter-specific and inter-generic transfer of the genetic material. Advancement of the modern biotechnological tools offers tremendous promise for elucidating these important weedy traits in detail and further exploration for the various aspects of crop improvement in 'cut and paste' style.

Weeds are harder plants, co-existing with crops and out-compete them in almost every aspect. Competitiveness and tolerance to abiotic and biotic factors are the important traits which can be observed among various weed species and can be transferred into crop plants. Co-existence of the weeds with crop plants provide an edge over the other wild species and model species like *Arabidopsis thaliana* ensuring the better chance of integration of the transferred material and survival of the transgenic with minimum yield penalty. However, success of such approaches requires collaborative efforts from all the corners of plant science to bring together expertise in weed science, molecular biology and plant physiology. An effort has been made to point out the useful traits of the weeds which can be transferred into crop plants for improvement along with the few successful case studies.

L - 32

New Molecules in weed management

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High production agriculture characterized by growing dwarf or semi dwarf cultivars, responsive to increased applications of irrigation and fertilizer has simultaneously increased the problem of weeds. The dominance of little seed canary grass (*Phalaris minor*) in wheat and barnyard grass (*Echinochloa* spp.) in rice are a case in point. The control of these weeds through conventional means is difficult. Herbicides such as isoproturon in wheat and butachlor and anilofos in rice have been increasingly used to manage the problem. The use of chemicals to control weeds is increasing in almost all crops. Wheat, rice and tea are the major crops where maximum amount of herbicides are used in the country. The use in crops like onion, groundnut, soybean, cumin is showing a steady increase. The consumption of herbicides is likely to increase in the future due to the unavailability of labour in rural areas during peak crop season. The evaluation of new molecules is a continuous process and their commercialization is important in Indian agriculture. In present weed management scenario the use of low dose molecules contributes more.

Carfentrazon is a relatively new herbicide that controls broadleaf weeds primarily through the inhibition of the protoporphyrinogen oxidase enzyme in cereals. The study conducted at various DWSR centres revealed that cyhalofop butyl and metamifop are effective herbicide for post emergence control of *Echinochloa* in rice. Like wise herbicide mixtures are now a-days play an important role in single shot of application. For example fomasofen +fluazifop-butyl and saflufencil+imazethapyr in soybean, Application of cyhalofop butyl could bring down the population of *Echinochloa* drastically. However, in the treatments, where cyhalofop butyl was combined as tank mix or as follow up with 2, 4-D the effect on *Echinochloa* was adversely affected. On the other hand when 2,4-D application was delayed by 3, 6, 9, 12 or 15 days this antagonistic effect could be avoided. Application of carfentrazon+sulfosulfuron, metsulfuron+sulfosulfuron, clodinafop+sulfosulfuron in wheat resulted in a better weed control efficiency.

A reduction in herbicide rates, with efficacy maintained would be beneficial because of savings resulting from less herbicide use. Reducing herbicide rates may be achievable for several reasons, including (1) registered rates have been made to ensure satisfactory weed control over a wide range of environmental conditions, (2) maximum weed control is not always necessary for optimal crop production, and (3) there is a critical time period during which weed control is essential for profitable crop production. However, reducing herbicides rates resulted in increased weed infestation if not supplemented with other weed control methods. Great efforts have been made to determine the efficacy and risk of using herbicides at rates below the manufacturer’s suggested use rates, although most of this kind of work has been conducted in corn (*Zea mays*) and soybean (*Glycine max*) weed growth stage, as well as temperature, relative humidity, and soil water content, affect the weed’s susceptibility to herbicides and should be considered when implementing reduced rate herbicide programme.

L - 33 Herbicide tolerant crops: opportunities and challenges

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Weeds not only compete with crops for water, nutrients, sunlight, and space but also are the abode of insect and disease pests. This has resulted in crop damage which in extreme cases have been reported to be up to 100 per cent. Therefore effective and timely weed management is the most important consideration for maximizing the yield in the crop protection system. In recent times the farmers have been facing difficulties in pursuing mechanical weeding due to substantial increase in cost of labour and more importantly the non-availability of labour at critical times of the crop. Farmers have also found it difficult to enter the field to undertake weeding operations when there is excess rain during monsoon season. Manual weeding practices can also lead to disturbance of soil and pruning of root tips during active crop growth period.

Chemical herbicides have offered a very remunerative option for weed control to Indian farmers and is being used in crops like Wheat, Rice, Soybeans, Vegetables, Tea, Cotton, Maize and Sugarcane mainly in the irrigated areas. The use of herbicides in rain fed areas is also gaining importance. However there are certain limitations in herbicide use practices for soil-active herbicides that depend on moisture for activation in the field . The window of application for pre emergent herbicide is a limited period of time i.e. 2-3 days of planting the crop which can cause problems in certain weather situations. Any weed control measure taken after the critical weed control period leads to unrecoverable loss to productivity. Under such conditions use of an effective post-emergence herbicide is a good option for the farmer to control the weeds during the critical stages of the crop. The best candidate for post emergence herbicides should be having no or minimal residual activity in the soil.

Alternate new technologies using biotech approaches like herbicides tolerant crops with broad spectrum non-selective and non- residual herbicides were discovered which complements with existing weed management practices & have proved to be cost effective solutions in many countries. International Service for the Acquisition of Agri-biotech Applications (ISAAA), recently mentioned that herbicide tolerance has consistently been the dominant trait from the genesis of commercialization in 1996 to 2011, In 2011, herbicide tolerance deployed in soybean, maize, canola, cotton, sugarbeet and alfalfa, occupied 59% or 93.9 million hectares of the global biotech area of 160 million hectares. The interesting fact is that out of the 29 countries planting biotech crops in 2011, 19 were developing and 10 were industrial countries. Herbicide tolerance technology has consistently delivered excellent benefits to farmers across the globe. Herbicide-tolerant (HT) crops offer farmers a vital tool in fighting weeds and are compatible with no-till methods, which help preserve topsoil. They give farmers the flexibility to apply herbicides when needed, to control total input of herbicides and to use herbicides with preferred environmental characteristics. The technology will be very useful in agriculture even for small/marginal farmers.

The advent of these herbicide tolerant crops has allowed farmers to control weeds more effectively usually with only one herbicide application at a significantly lower cost. These crops can also make a very important contribution to sustainable farming systems. The use of these crops is compatible with farming systems that reduce or eliminate the need for tillage or cultivation, which in turn are helpful in reducing soil erosion, conservation of moisture, nutrients and soil structure. The use of herbicide tolerant crops are one of the powerful and important components of Integrated Pest Management (IPM) farming systems that enable farmers to implement long term sustainable systems of crop production. Experience in some countries reveal that introduction of herbicide tolerant crops in conjunction with no-till has resulted in significant benefits and management flexibility. The herbicide tolerant crops are fully compatible with no-till systems and encourage soil conservation.

With any new technology there are often significant benefits and sometimes challenges and this is true for the crops developed with the help of biotechnology. Herbicide tolerant crops have generally been enthusiastically embraced by farmers because they haveprovided significant economic benefits. The policy decision taken recently in India requiring the No Objection Certificate (NOC) from respective States for even conducting field trials is an significant obstacle in the process of regulatory approval system. The social activist groups and NGOs further continue to spread misinformation by continuing anti-GM programs and propaganda in collaboration with like-minded environmental institutions and civil society organizations. Lack of clarity in the existing system cripples the progress lowering the confidence of public and private sector in the country. The media further add complications by publicizing inadequate and in many cases false information that negatively impacts the public's opinion of the technology which slows regulatory actions.. The engagement of the public scientific communities to ensure that the scientific facts are presented to the public will greatly influence public acceptance of these technologies and thus impact the speed upon which these technologies can be available to farmers.

In countries where approved, glyphosate herbicide has sometimes been used as the sole method of weed control for many years in glyphosate tolerant crops. This has increased the chance of developing resistance in few of the weed species. In order to reduce the evolution and spread of glyphosate resistant populations, broad based stewardship programs have been implemented to encourage farmers to implement diversified programs. In India, we will also need to evaluate our strategies to explore the potential of these crops and develop weed resistance management strategies in advance by incorporation of various components of weed management tactics that include the use of glyphosate in combination with weed management methods, such as hand hoeing and mechanical cultivation, and/or with other herbicides to ensure best weed management programs.

In this context we need to understand that any new technology has advantages and challenges. We need to focus on proper evaluation and if it provides value to our farmers and country as a whole, we should not hesitate to accept, manage, and steward the technology for the long term. We believe that this is the right time to discuss and debate more about herbicide tolerant crops and evaluate these crops for their benefits to farmers of our country in order to remain self reliant and to feed increasing population. The weed scientist can play a vital role in educating public about nuisance of weeds and importance of weed management practices including herbicide tolerant crops.

L - 34 Best weed management practice (BWMP) of major weeds under various ecosystem in inceptisol of West Bengal

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Global food security in agriculture has to face new challenges for developing countries like India of 1.21 billion (2011 Census, Government of India -17.7 % more than 2001 Census) & in world of 9 billion people by 2050 and this is an arduous task. India has achieved 3.2% average annual growth in agriculture and allied sectors in the first four years of the 11th Five Year Plans but this is still below the targeted growth rate of 4%. It is also true that productivity of food grains in India has increased by about 10% to 1921 kg ha^{-1} in the last four years but the yield of most crops are still lower than the world average The 'System of Intensification' through Best Management Practice (BMP) of the available resources (Rainbow Revolution) is the best alternative methodology to overcome our food security problem. Management of weed is one of the key factors for BMP. Weed, the major pest, causing yield reduction 37 % among the pests and to the tune of 78%. Weed infestation is more severe in upland ecosystem (71%) than in wetland. In Gangetic alluvial soil the yield loss is hovering around 40-45%. Climate change is going to affect livelihoods and food security of millions of farmers and fisher folk, but unless immediate steps are taken, the agricultural (contributing more than 25 % in global warming) operations will continue to add (invasion of pests) to the problem of global warming.

In anaerobic ecosystem during rainy season among the monocots Brachiaria platyphylla , Echinochloa spp. Ischaemum rugosum, etc. and among the dicots Alternanthera philoxeroides, Ammania baccifera, Cyanotis axillaris, Eclipta alba, Hypericum japonicum,etc. are most common. In aerobic crop fields during winter and summer and in uplands during rainy season the dominant weeds are *Cyperus rotundus, Digitaria* spp..*Echinochloa colona, Eleusine indica, Dactyloctenium aegyptium, Ageratum conyzoids, Alternanthera* spp.*, Amaranthus* spp. *Argemone mexicana, Chenopodium album etc.*

Hand weeding is very common among the Physical method. In SRI the mechanical method (various paddy weeders) is widely used. Ecological methods are very useful as it increases the soil health by crop diversification technology, more particularly using the legumes either as intercrops or as mixed crop or as Guard crop etc. Chemical weed control is becoming more acceptable to farmers among all other pesticides. During 2007-11 considering the average from 142 experiments 39.27 - 58. 95 % WCE and 52.61 % more yield in chemical herbicides plot was observed showing the advantage of application of PE herbicides. Averaging of all POE herbicides applied to different field crops 48.02 - 67. 31 % WCE for EPOE & 39. 68 - 71. 34 % WCE for POE and 50.66 % more yield in chemical herbicides plot was recorded proving the advantage of application of POE herbicides. Utilization of weed in human welfare is another important options for managing many pernicious weeds In conclusion for best weed management practices (BWMP) training & awareness to improve the farmers thinking, the seed bank study, survey on new invasion of weed flora, annual planning of weed management, critical crop weed competition period of different crops and environment safety are the major factors to be considered. In general utilization of weeds in human welfare, diversification of crops, the use of mechanical weeding as POE and chemicals either the botanicals or safer synthetic chemical herbicides are gradually becoming more acceptable and also have tremendous prospects to replace the traditional costly, time consuming and tedious hand weeding to increase the productivity of major crops in Inceptisol without much disturbing the biodiversity and environment.

O - 1 Weed management in rice in India – a review

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Rice is cultivated in India in a very wide range of ecosystems using direct-seeded and transplanted methods of establishment. Irrespective of the environment and the methods of rice establishment weeds are major constraints hindering the efforts to enhance rice productivity and production in India. The research carried out on weed management in rice in India during the past three and half decades is reviewed. Rice yield losses range from 12% to complete crop failure depending on method of rice establishment and the ecosystem. Rice yield losses due to weeds were reported to be higher under dry direct-seeded rice and relatively less with transplanting method of establishment. *Echinochloa colona* and *E. crus-galli* are the most serious weeds affecting rice in all methods of rice establishment. Other weeds of major concern in rice in India are *Ammannia baccifera*, *Cyperus iria*, *Cyperus difformis*, *Eclipta alba*, *Fimbristylis miliacea*, *Ischaemum rugosum*, *Leptochloa chinensis, Monochoria vaginalis*, *Paspalum distichum* and *Spaenoclea zeylanica*. *Cyperus rotundus* and *Cynodon dactylon* are other major problems in upland conditions, particularly in poorly managed fields. First thirty to seventy days are critical for crop weed competition, depending of the type of rice cultivar and the method of rice establishment. Reported research is primarily focussed on chemical method of weed management in rice in India. Anilofos; butachlor; chlorimuron+metsulfuron; cyhalofop butyl; 2,4-D EE; ethoxysulfuron; fenoxaprop-p- ethyl; fentazamide; flufenacet; fluroxypyr; oxadiargyl; oxyfluorfen; pendimethalin; pyrazosulfuron; quinclorac; thiobancarb were some of the herbicides reported to be effective in managing weeds in different method of rice establishment. Several effective integrated weed management methods combining preventive, cultural, mechanical and biological weed control methods in an effective, economical and ecological manner were also identified. The need for basic on-farm studies to understand ecology of weeds in rice agro-ecosystems of India and develop ecological weed management approaches is emphasised.

O - 2 Bio- efficacy of pendimethalin CS against weeds in transplanted chillies and its residual effect on succeeding jowar crop

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A field experiment was conducted during *Kharif* 2008-09 and 2009-10 to study the bio-efficacy of pendimethalin 38.7% CS at four rates (483, 580.5, 677.25 and 1354.5 g/ha) in comparison with pendimethalin 30% EC 750 g/ha alone and followed by (*fb*) inter-cultivation at 30 and 60 days after transplanting (DAT). Fluchloralin 45% EC 1125 g, trifluralin 48% EC 960 g/ha and weedy check on transplanted chillies and their residual effect on succeeding jowar crop in a randomized block design with three replications. Results indicated that pre-planting application of pendimethalin 38.7% CS 483 to 1384.5 g/ha significantly reduced the weed growth and increased dry pod yield of chillies ranging from 62 to 206% compared to weedy check without any crop injury. Among the different doses, pendimethalin 38.7% CS at 1354.5 g/ha recorded the highest pod yield (2717 kg/ha) and was on par with its lower dose of 677.25 g/ha (2407 kg/ha) and these treatments were significantly superior to other doses of 483 and 580.5 g/ha. The unchecked weed growth throughout the crop growing period caused 78 percent reduction in dry pod yield compared to recommended practice of pendimethalin 750 g/ha *fb* inter-cultivation at 30 and 60 DAT. Residual effect of pendimethalin 38.7% CS was not observed on germination and growth of succeeding jowar crop.

O - 3 Effect of time of sowing and weed management on direct seeded rice

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A field experiment was conducted during *Kharif* seasons of 2008 and 2009 at University farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur on inceptisol to study the effect of sowing time and weed control practices on weed flora and grain yield o f direct seeded rice. The soil of the experimental field was sandy loam (inceptisol), low in available N (208 kg/ha), medium in available P (17.6 kg/ha) and high in available K (321 kg/ha) with a P^H of 7.1. The experiment was laid out in a split plot design comprising two levels of time of sowing (sowing before onset of monsoon and sowing after onset of monsoon) in main plots and seven levels of weed management (pretilachlor-S 0.5 kg/ha PE, butachlor 1.5 kg/ha PE + 1 HW, fenoxprop-p-ethyl 60 g/ha POE + (chlorimuron-ethyl + metsulfuron-methyl), cyhalofop 90 g/ha + 2,4-D 0.5 kg ha at 30 DAS, azimsulfuron 35 g/ha , Weedy check and hand weeding twice at 20 and 40 DAS) in sub-plots. The treatments were replicated thrice. *Echinochloa colona, Ischaemum rugosum*, *Alternathera triandra, Cynotis axillaries, Commelina benghalensis* and *Cyperus iria* were the predominant weed species observed in the experimental field. Though, the dry matter of weeds at harvest did not differ significantly between pre and post-monsoon sown rice crop but seed yield was significantly higher by 15.41% under post monsoon than pre-monsoon sown crop. The treatment of two hand weeding registered significantly lowest dry matter than rest but was comparable with the treatment of Butachlor 1.0 kg/ha *fb* one hand weeding at 60 DAS. Accordingly, significantly higher seed yield was recorded from two hand weedings but was at with Butachlor 1.5 kg/ha *fb* one hand weeding. Post-emergence application of fenoxaprop 60 g/ha + chlorimuron + metsulfuron 4 g/ha and cyhalofop-p butyl 90 g/ha + 2, 4-D 0.5 kg/ha 30 DAS were next, in order.

O - 4 Natural plant oils: broomrape killers?

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The effect of natural plant oils on broomrape (*Orobanche cernua* Loefl.) was assessed in a naturally infested tobacco (*Nicotiana tabacum* L.) field at the Agricultural Research Station, Nipani, Karnataka. Natural plant oils which are biodegradable and available at low cost differed in their ability to kill the young broomrape spikes. Neem (*Azadirachta indica* Juss.), coconut (*Cocos nucifera* L.), and sunflower (*Helianthus annuus* L.) oils showed knock down effects on the bud part of the parasite within 2-3 days, gastor (*Ricinus communis* L.) and niger (*Guizotia abyssinica* (L.fil. Cass) oils killed the buds within 3-4 days. Mustard(*Brassica juncea* (L.) Czernjaew) oil took 5 days to kill the bud.Coconut and sunflower oils also killed the broomrape stam more quickly than niger and castor oils. Neem oil and mustard oil did not kill the stem part of the parasite. These findings give new information on relative efficiency of different plant oils in controlling broomrape. None of oils was phytotoxic to tobacco. After optimization of application techniques, the use of such oils in practice will be cheap, environmentally safe and effective.

O - 5 Parthenium menance in north-east India and efforts of its management through biological control based approach

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Parthenium hysterophorus L.is an alien invasive herbaceous weed causing severe health hazards and environmental problem. The objective of this study were to make a systematic survey of 12 National highways and 3 railway tracks of North-Eastern India during 2009-2011 and thereby make an effort to manage it using biocontrol agents (botanical agents, *Zygrogramma biocolorata* and some selected fungi). Studies have revealed that growth of *Parthenium hysterophorus* L. was found growing luxuriantly along the surveyed sites. Aqueous extracts of different botanical agents like *Gynura cusimba, Amaranthus spinosa, Mimosa pudica, Cassia tora, Cassia occidentalis, Sida spinosa, Riccinus communis, Xanthium strumarium, Cassia sericeae, Chromolaena.* Sp and *Urena lobota* at different concentration were studied for their allelopathic effect against *Parthenium*. 100% inhibition of Parthenium seed germination were recorded at 20% of leaf and stem extracts of *Riccinus communis*, *Cassia sericeae, Mimosa pudica* and *Cassia tora*. Leaf and stem extracts of *Amaranthus spinosa, Cassia tora, Mimmosa pudica* and *Riccinus communis* showed maximum inhibition on root and shoot growth of Parthenium even in low concentration. Leaf and stem extracts of *Riccinus communis, Amaranthus spinosa* and *Cassia sericeae*, stem extract of *Mimosa pudica* and *Cassia tora* showed maximum effect in reducing vigour index and dry matter production of Parthenium as compared to control. Among the tested botanical agents *Cassia sericeae, Riccinus communis, Mimosa pudica, Cassia tora,* and *Amaranthus spinosa* showed maximum allelopathic effect. The efficacy of certain fungal metabolites *viz., Aspergillus niger, Trichoderma viridae, Penicillium* sp, *Fusarium oxysporium, Alternaria alternata* were tested against Parthenium. *M*aximum inhibition on seed germination and seedling growth of Parthenium was observed in *Fusarium oxysporium*. Different stages of *Zygograma bicolorata* i.e. adult and larvae were tested against Parthenium in net cage condition. It was observed that there was great reduction in plant height, shoot length, root length and biomass due to significant defoliation of Parthenium leaves except the midribs.

O - 6 Biological management of water hyacinth by use of pathogenic microbes

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Water hyacinth (*Eichhornia crassipes*) is one of the most predominant, persistent and troublesome aquatic weeds. Among different control methods available, biological method using native pathogens is the most viable and environmentally safe method. Periodical surveys of various water bodies in and around Jabalpur lead to the isolation of four important fungal pathogens, *viz., Cochliobolus* sp. *Fusarium* sp., *Curvularia* sp. and *Alternaria* sp. on water hyacinth plants. The pathogens were evaluated for their pathogenicity on water hyacinth and further the pathogens were integrated with the insect pest *Neochetina bruchii* to study their combined effect on the target weed. Results indicated that all the four organisms were found to infect and kill water hyacinth, though at varying intensities. Among the organisms, *Cochliobolus* was found to be very aggressive and when applied as a consortia with the other three pathogens, was found to be very effective and kill the entire population of about 15 plants in an aquatic tank of size of 3 feet diameter . *Fusarium* sp which is a vascular pathogen can be used as a major agent in the consortia because being a vascular pathogen; it is capable of rapidly killing the individual plants in 15-20 days of inoculation. However *Fusarium* was not very effective in its spread to other plants and hence when there was no infection in the new rammets. There was no complete killing of all the plants in the in causing disease in non-injured plants. Neochetina beetles when applied before 10 days of fungal treatment were found to act as facilitator for the fungal pathogens to enter the plants and kill them rapidly.

O - 7 Comparative effect of soil solarization, herbicides and incorporation of various plant materials on weed growth and productivity of soybean

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An investigation was carried out during *Kharif* 2006 to study the effect of soil solarzation, herbicide application and incorporation of various plant materials on weed growth and productivity of soybean at the Research Farm of Indian Agricultural Research Institute, New Delhi. The experiment was laid out in a randomized block design on a sandy loam soil with twelve treatments and was replicated four times. Soybean (*Cv*. Pusa 9712) at 100 kg/ha was sown on July 15, 2006 at row spacing of 50 cm. The recommended doses of 30 kg N, 80 kg P_2O_5 and 60 kg K_2O/ha was applied as basal dressing in soybean. Soybean was infested with *Triantherma portulacastrum, Dactyloctenium aegyptium, Digitaria sanguinalis, Commelina benghalensis, Amarnthus, spinosus, phyllanthus niruri* and *Digera arvensis.* Hand weeding twice was on a par with pre-emergence application of ready mix of pendimethalin+imazethapyr (1.0 + 0.02 kg/ha) and pendimethalin application alone at 1.5 kg/ha. The solarization of soil for 40 days during May-June with transparent polyethylene film (TPE) of 0.05-0.10 mm thickness significantly reduced the weed density. Among the plant materials, incorporation of *Dalbergia sisoo* (sheesham) dried leaves 4 t/ha resulted in the highest reduction in weed density followed by Parthenium, Eucalyptus, neem leaves and sunflower stalk. Hand weeding twice recorded the highest seed yield of soybean (2.26 t/ha), which was on a par with that of pre-emergence application of ready mix of pendimethalin+imazethapyr (1.0+0.02 kg/ha) and pendimethalin alone at 1.5 kg/ha. Pre-plant incorporation of fluchloralin at 1.25 kg/ha and soil solarization were on a par in terms of seed yield of soybean. Among the plant materials, Eucalyptus 4 t/ha recorded the highest seed yield of 1.54 t/ha, which was closely followed by incorporation of Sheesham dried leaves. Incorporation of Parthenium dried leaves and neem leaves resulted in poor crop stand.

O - 8 Role of fungal pathogens of water hyacinth in integrated biological control of the weed in South Africa

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Waterhyacinth, *Eichhornia crassipes* (Mart.) (Solms-Laub.) (Pontederiaceae) continues to be the worst aquatic weed world-wide. In South Africa the biological control programme was initiated in 1973 and since then, six arthropods and one pathogen have been released in an attempt to reduce infestations. Despite all efforts the results have been variable and more control agent species are being considered for release. Although significant research has been undertaken using the insect biocontrol agents of waterhyacinth, the role that native phytopathogenic fungi play has been neglected in South Africa. During recent studies we obtained 250 isolates of fungi from diseased plants of waterhyacinth collected during several field trips throughout South Africa during 2010-11. The fungi were evaluated for their efficacy against waterhyacinth, their potential for commercialization (performance under field conditions, specificity and host range, ease of inoculum production), and their compatibility with insect biocontrol agents of the weed. Preliminary pathogenicity show several isolates to be promising agents, including *Alternaria eichhorniae*, *A. alternata*, *Acremonium zonatum*, *Bipolaris hawaiiensis* and *Fusarium* spp. Although most of these isolates appeared severely damaging under controlled conditions their inability to serve as stand-alone replacements for chemical herbicides, has probably deterred their earlier commercialization efforts.. Our studies under controlled conditions showed potential their complementary effect with the *Neochetina* spp and *Eccritotarsus catarinensis*, insect biocontrol agents of waterhyacinth. Thus their use as supplements with insects for effective biological control of waterhyacinth is highly recommended.

O - 9 Effect of seed rate and weed control methods on productivity and profitability of wet land rice under medium land condition

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The experiment was conducted during rainy seasons of 2010 and 2011 with treatments comprised of four levels of seed rates i.e. 60, 80, 100, and 120 kg/ha and five weed management practices i.e. butachlor 1.5 kg /ha pre emergence, Pyrazosulfuron 0.02 kg/ha post emergence, Almix (chlorimuron + metsulfuron) 4 g/ha post emergence, two and weedings at 20 and 40 days after sowing and weedy check. The experiment was conducted in a randomized block design replicated thrice. Treatment comprising of seed rate were put in one factor and weed control practices in another factor. The rice variety was 'Lalat. The soil was low in available nitrogen (242.2kg/ha) and potassium (123.00kg/ha) and medium in available phosphorus. The recommended dose of fertilizers 100 kg N, 60 kg P_2O_5 and 40 kg/ha were applied in the form of urea, di ammonium phosphate and muriate of potash respectively. 80 kg seed being similar to 100 and 120 kg seed /ha recorded significantly reduced weed density compared to 60 kg seed/ha. The mean of total weed observed under 80, 100 and 120 kg seed/ha recorded 56.69% at 40 days after sowing and 22.00% at 60 days after sowing reduced total weed density compared to 60 kg seed/ ha. The mean reduction of grassy, broad leaved and sedges weeds at 40 days after sowing were 52.32, 35.27 and 33.47% respectively at 40 days after sowing while, at 60 days after sowing the density of grassy, broad leaved and sedges weeds reduced to the extent of 54.86, 19.80 and 22.00% respectively. Pyrazosulfuron 0.20kg/ha being similar to Almix 4g/ha at 20 and 40 days after sowing also similar with two hand weeding recorded 61.03, 66.37 and 74.25% at 20 days after sowing; 40.14, 6.4 and 59.15% at 40 days after sowing and 48.68, 40.53 and 51.87% at 60 days after sowing significantly reduced total weed density compared to butachlor 0.5kg/ha, hand weeding and weedy check respectively. 80 kg seed/ha being at par with 100 and 120 kg seed/ha recorded 24.17 and 28.04% significantly reduced dry matter accumulation by weeds compred to 60 kg seed/ha at 40 and 60 days after sowing respectively. Among weed control methods, application of pyrazosulfuron0.20kg/ha being similar to butachlor 0.5kg/ha, Almix 4g/ha and hand weeding recorded 70.38, 87.10 and 81.00% significantly reduced dry matter accumulation by weeds compared to weedy check. Rice crop sown with 80 kg/ha being similar to 60 and 100 kg/ha recorded 23.53% significantly higher effective tiller compared to 120 kg seed/ha. 80 kg seed/ha remaining similar with 100 kg/ha registered 635 and 24.47% higher grain (2701 kg/ha) and 70.96% and 35.79% higher straw (3809 kg/ha) yield compared to 60 and 120 kg seed/ha respectively. Among weed control methods, application of pyrazosulfuron0.20kg/ha being similar to butachlor 0.5kg/ha, almix 4g/ha and hand weeding recorded 107.90% higher grain (2867 kg seed/ha) and 110.10% higher straw yield compared to weedy check, thereby registering maximum net return (Rs. 24,147 /ha) and B:C ratio (2.21). it can be concluded that rice crop sown as direct seeded under wet land condition a seed rate of 80 kg/ha and among weed control application of pyrazosulfuron 0.20kg/ha was most productive and profitable.

P - 1

Phyto-sociology and seed production potential of weeds of vegetables in lateritic belt of West Bengal

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To generate information on the weed infestation, dominance and seed production potential of important weed species in different vegetables, the present study was conducted in Birbhum and part of Burdwan district under lateritic region of West Bengal during 2009-2010. The result revealed that altogether 38 species (broad leaved – 29, grass – 6, sedge – 3) belonging to 32 genera and 18 families infested winter and summer vegetables *viz.* cabbage, cauliflower, potato, tomato, brinjal, radish, spinach, onion, bhindi, red amaranth and red pumpkin. The diversity of the species was found with in the family *Poaceae* and *Asteraceae* (6 species in each), *Amaranthaceae* (5 species), *Papilionceae* and *Cyperaceae* (3 species in each), *Euphorbiaceae* and *Solanaceae* (2 species in each) and remaining families had one species each. The largest genus was *Cyperus* containing 3 species followed by *Amaranthus, Alternanthera, Gnaphalium* and *Vicia* (2 species in each). Most frequent species was *Cyperus rotundus, Anagallis arvensis* and *Digitaria sanguinalis* in winter and *Echinochloa colonum, Croton bonplandianum* in summer. The most dominant species on the basis of importance value indices (IVI) in both winter and summer vegetables was *Cyperus rotundus* followed by *Gnaphalium purpureum, Chenopodium album* and *Digitaria sanguinalis* in winter and *Echinochloa colonum, Croton bonplandianum* in summer. Seed production potential of 12 important species studied during harvesting of crop revealed that *Spergula arvensis* recorded the highest seed production (8036/plant) followed by *Solanum nigram* (4665) and *Gnaphalium indicum* (3864). Seed rain (number of seeds/m^2) was higher in *Spergula arvensis* (40180/m^2), *Gnaphalium indicum* (38640) and *Gnaphalium purpureum* (18096) as the number of plants / m^2 was higher at the time of harvesting of crop.

P - 2

Effect of poultry manure on weed dynamics in maize

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Maize (*Zea mays L.*) is one of the most important cereal crop grown all over the globe as poor man's food and also as cattle and poultry feed. Field investigation was carried out during *kharif* and *rabi* seasons of 2008 and 2009 on sandy clay loam soil at the irrigated upland farm of Eastern Block, Tamil Nadu Agricultural University, Coimbatore. The experiment was laid out in randomized block design, replicated thrice. The experiment consisted of ten treatments comprising four treatments of different organic manures and their combinations *viz.*,100% RDF through farmyard manure, vermin-compost and poultry manure and all the combination at 1/3, 1/3, 1/3 proportion. The four treatments were integrated i.e., 50 per cent RDF through organic manures and 50 per cent RDF through inorganic fertilizers. The remaining two treatments were 100 per cent RDF through inorganic fertilizers and control (without organic and inorganic). The application of organic manures and fertilizers in the *kharif* and *rabi* seasons of 2008 and 2009, significantly influenced the weed dry weights. Lowest dry weights of weeds and weed density was recorded with 100% RDF through poultry manure and it was comparable with 50 per cent RDF + 50 per cent RDF through poultry manure during both the years of study. This is due to when poultry manure is added, aerobic fermentation occurs with the production of heat and loss of CO_2 and ammonia. The heat produced and the immediate higher availability of N have caused the caustic effect on the germinating weeds and reduced the weed biomass. Another reason is that poultry manure is totally free of weed seeds because of the use of broken grains in poultry rations.

P - 3 Effect of integrated weed management on weed dynamics and yield of maize

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Fields experiments were conducted during *kharif* 2010 and 2011 at the Main Research Station, Hebbal, Bengaluru to evaluate the performance of herbicides for control of weed types, yield and economics of weed management practices in maize. The trial was laid out with eleven treatments comprising of oxyfluorfen 23.5EC 200 g, atrazine 50WP 1.0 kg and pendimethalin 30 EC 0.75 kg/ha (as pre-emergence at 3 DAS) alone or in combination with mechanical weeding at 30 DAS or post emergence application of 2,4-D Na salt 80 WP 0.5 kg ai/ha at 30 DAS in comparison to hand weeding (20 and 40 DAS) and unweeded control replicated four times in a RCBD design. Major weeds were *Cyperus rotundus, Cynodon dactylon, Eleusine indica, Digitaria marginata, Echinochloa colona*, *Commelina benghalensis, Ageratum conyzoides* and *Borreria articularis*. Mean data of two years indicated that all weed management practices resulted in significantly higher kernel yield than unweeded control due to effective control of weeds as evident from lower weed density (33.5 to 66.5/m^2 as against 95.0/m^2 in unweeded control at 60 DAS) and dry weight (16.6 to 37.4 g/m^2 as compared to 80.9 g/m^2 in unweeded control at 60 DAS). Hand weeding twice gave slightly higher kernel yield (7254 kg/ha), but comparable to pendimethalin, oxyfluorfen or atrazine along with mechanical weeding at 30 DAS (6858 to 6942 kg/ha) and oxyfluorfen fb 2,4-D Na salt at 30 DAS (6817 kg/ha). While other herbicides – pre-emergence of pendimethalin, oxyfluorfen or atrazine alone or pendimethalin or atrazine fb 2,4-D Na salt usage at 30 DAS gave slightly lower yields (5442 to 6510 kg/ha) than hand weeding (7254 kg/ha). Unweeded control gave lower kernel yield (3452 kg/ha, owing to severe competition from weeds of all types and had a weed index of 51%. The cost of pre-emergence herbicides alone (Rs.1150 to 2370/ha) or followed by mechanical weeding (Rs.2150 to 3370/ha) or 2,4-D Na salt application at 30 DAS (Rs. 1820 to 3040/ha) was cheaper than hand weeding (Rs. 6250/ha). Thus herbicides usage could save weeding cost to an extent of Rs. 2880/ha to Rs. 4600/ha over hand weeding

P - 4 Estimation of viable weed seeds in cultivated fields

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Knowledge of weed seed density present in soil and weed seed emergence pattern will help the farmer to know the optimum time to apply a herbicide or the weed control practice. Keeping this in view, an experiment was conducted during summer 2008, 2009 and 2010 with an objective to study the weed seed density in soil depth of 0-15 cm depth in different fields of Acharya N G Ranga Agricultural University, Regional Agricultural Research Station, Lam, Guntur, A.P. in a randomized block design with three replications. Soil samples from 0-15 cm depth collected randomly from different fields were spread over shallow trays for germination of weed seeds. Observations were recorded species wise emerged weeds. After observation, all weed seedlings were uprooted and the soil was treated with GA_3 at 100 ppm to induce germination of the dormant weed seeds and observations were recorded as number of weeds germinated per kg of soil. Results indicated that there is a significant difference in total weed seed in different fields of RARS, Lam. Significantly the highest weed density was observed in field No.3 before and after GA_3 treatment. Among different weed groups, broad leaf weeds were dominant than grasses. Among the different weed species observed. *Trainthema portulacastrum, Digera arvensis* (BLW)*, Echinochloa colona, Dinebra retroflexa* (grasses) were the predominant species.

P - 5 Effect of rice establishment techniques on crop productivity and weed dynamics under different weed control methods in Uttarakhand

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A field experiment was conducted at Norman Ernest Borlaug Crop Research Centre, Govind Ballabh Pant University of Agriculture & Technology, Pantnagar (U.K.) with an aim to find out the effect of different rice establishment techniques on crop productivity and weed dynamics under various weed control method during *kharif* 2010. Total 16 treatments consisted with 4 rice establishment techniques (system of rice intensification (SRI), transplanting method direct dry seeding (unpuddled) and wet seeding through drum seeder (sprouted seed sown in puddle situation) and 4 weed control methods (pyrazosulfuron (25 g/ha) + conoweeder (40 DAT/DAS), twice conoweeder (20 and 40 DAT/DAS), twice hand weeding (20 and 40 DAT/DAS) and weedy check) were tested in strip plot design with 3 replications. The pre-dominant weed species in the experimental plots were *Echinochloa colona*, *Echinochloa crus-galli* and *Leptochloa chinensis* among grasses, *Ammania baccifera*, *Caesulia axillaris* and *Alternanthera philoxiroides* among broad leaved weeds and *Fimbristylis miliacea* and *Cyperus rotundus* among sedges at 60 DAT/DAS. Significantly higher grain yields (4492 kg/ha) was found with SRI method among all the establishment methods followed by transplanted rice with grain yields of 3833 kg/ha which was also higher than those obtained with wet seeded rice (3610 kg/ha). Direct dry seeded rice produced the lowest grain yields (2815 kg/ha) among all the 4 establishment techniques tested. Productivity of rice between different weed control methods, twice hand weeding (20 and 40 DAS/DAT) produced maximum grain yields (4434 kg/ha) followed by pyrazosulfuron + conoweeder (4184 kg/ha), conoweeder (3863 kg/ha) and weedy check (2270 kg/ha).

P - 6 Biology and management of *Caesulia axillaris* and other weeds in transplanted rice under *'tarai'* conditions of Uttarakhand

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A pot culture experiment was conducted only to study the growth and developmental pattern of *Caesulia axillaris* Roxb., at Department of Plant Physiology, College of Basic Sciences and Humanity and one field experiment was also conducted at Crop Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar, Udham Singh Nagar (Uttarakhand) to study the management of *Caesulia axillaris* and other weeds in transplanted rice. *Caesulia axillaris* was found to be dominant weed of transplanted rice in *'tarai'* region of Uttaranchal. It is an annual, dicot, glabrous semi-aquatic herb of family compositae which grows vigorously and infest wetland rice. It grows upto the height of 50 cm and have on an average 7.0 branches per plant thus accumulating large biomass and impose serious competition for various resources i.e. nutrients, light, space, CO_2 *etc.* against transplanted rice. Other important weeds were *Echinochloa crusgalli, E. colona, Cyperus* spp. and *Paspalum distichum. Caesulia axillaris* along with other weeds controlled effectively mainly by application of metsulfuron methyl at 8.0 or metsulfuron methyl + chlorimuron ethyl at 8.0 g/ha when applied at 2-3 leaf stage of *Caesulia*. Application of these herbicides resulted in reduced crop-weed competition and ultimately higher grain yield. Maximum reduction in weed density and dry matter was observed in two hand weeding treatments followed by metsulfuron methyl at 8.0, metsulfuron methyl + chlorimuron ethyl at 8.0 and 2,4-D at 500.0 g/ha were found to be most effective in controlling all types of weeds in decreasing order. Highest grain yield was recorded in treatment receiving metsulfuron methyl at 8.0 g/ha and metsulfuron methyl + chlorimuron ethyl at 8.0 g/ha which were statistically at par with weed-free treatment.

P - 7 Effect of nutrient management and cropping system on weed dynamics in rice based cropping systems

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A field experiment was conducted with four different rice based cropping systems (CS_1-green manuring sunhemp-rice-wheat, CS_2-rice-chickpea-sesame, CS_3-rice-berseem, CS_4-rice-veg.pea-sorghum) and three nutrient managements (M_1- 100% organic{1/3 N through each of FYM, vermi compost and neem oil cake}, M_2-100 % inorganic{100 % NPK through fertilizers, M_3-INM(50%NPK through fertilizer+50% N through organic sources) with un-replicated strip plot design at research farm, J.N.K.V.V, Jabalpur (M.P) in the year 2009-10 and 2010-11 to evaluate the effect of change in cropping system and nutrient management on weed flora, weed intensity, weed biomass, nutrient uptake and weed control efficiency. In the rice based cropping system season dominant weed species in *kharif* were *Cyperus iria, Cyperus difformis, Fimbristylis miliacea, Echinochloa colona, Eleusin indica, Digitaria sanguinalis, Celosia argentea* and *Euphorbia hirta.* In *rabi* season the CS_1-green manuring sunhemp-rice-wheat and CS_3-rice-berseem had maximum weed intensity and weed dry weight as compared to CS_2-rice-chickpea-sesame and CS_4-rice-veg.pea-sorghum. During summer season, the intensity and dry matter of weeds was more at 30 DAS and at maturity in CS_4-rice-veg.pea-sorghum. The weed intensity and weed dry matter were maximum in all the three seasons in M_{1-}100% organic {1/3 N through each of FYM, vermin-compost and neem oil cake}, which reduced in M_3-INM {50%NPK through fertilizer+50% N through organic sources} and M_2-100 % inorganic {100%NPK through fertilizers in a decreasing order. While considering the economics the CS_2 with M_2 resulted the highest GMR (23493 Rs/ha), NMR (170200 Rs/ha) with a B: C ratio of 4.5 as compared to all the other cropping systems and nutrient managements. It was obtained that introduction of change in rice-wheat system under organic and INM can reduce the weed intensity and biomass and can control perennial weeds in the cropping system.

P - 8 Studies on weed flora and crop weed competition in mulberry

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A field survey was carried out in mulberry maintained in Block A, B and C at Department of Sericulture, University of Agricultural Sciences, Bangalore during 2010-11. The major weed flora observed were *Cyperus rotundus* (a sedge); *Cynodon dactylon1 Dactyloctenium aegyptium Chloris* barbata, *Echinochloa colona*, Digitaria marginata (among grasses); *Parthenium hysterophorus*, *Phyllanthus niruri., Euphorbia geniculata, Euphorbia hirta Borreria stricta, Spilanthes calva* and *Tridax procumbens* of weed flora, *C. rotundus, C. dactylon, D.marginata*, *E.hirta* and *S.calva* were dominant weeds occurring in mulberry crop. To know the critical period of weed completion, five treatments namely weed free for first 20 days, 40, 60 and 75 days after pruning in relation to weedy check, were tried in RCBD with four replications. Averaged over *kharif* and summer seasons of 2010-11, leaf yield was maximum in plot kept weed free for 75 days (6.45 t/ha), followed by 60 days (5.49 t/ha), while weedy check lowered the leaf yield by 70% as compared to weed free upto 75 days Thus, mulberry require a weed free period of 60-75 days for obtaining higher leaf yield in red sandy loam soil under protective irrigation.

P - 9

Identification of invasive alien weed flora of Greater Hyderabad, Andhra Pradesh

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IUCN defines alien invasive species as an alien species which becomes established in natural or semi-natural ecosystems or habitat, an agent of change, and threatens native biodiversity. Introduction of these species may occur accidentally or through their being imported for a limited purpose and subsequently escaping, or deliberately on a large scale. Invasive alien species are the second largest cause to biodiversity loss in the world and impose high costs to agriculture, forestry, and aquatic systems. Introduced species are a greater threat to native biodiversity than pollution, harvest, and disease combined. Therefore, the study was carried out during 2009-11 to identify the invasive weed flora in the Greater Hyderabad. The present study revealed that 245 weed species spread over 177 genera belonging to 60 families of Magnoliophyta. Of the 245, the class Magnoliopsida comprises 202 species belonging to 143 genera and 48 families and the remaining the class Liliopsida comprises 43 species belonging to 34 genera and 12 families. There are about 191 species of herbs, 22 species of under shrubs, 11 species of shrubs, and 21 species of climbers and twines. Maximum weeds recorded from the family Fabaceae with 32 species, 26 species from Asteraceae, 13 species from Amaranthaceae and 11 species from Euphorbeaceae. Out of 245 weed species 109 weeds are aliens. Of these 21 weed species from Asteraceae, 16 weed species from Fabaceae, 7 weed species each from Convolvulaceae and Poaceae and 6 weed species each from Amaranthaceae and Solanaceae. About 44% of the Greater Hyderabad weed flora constitutes aliens, of which 73% are American, 15 % African and remaining from Mediterranean, European, Brazilian, West Indian, Peru and Medagascar weed species. The following alien weed flora were found to dominate causing threat to native vegetation in study area *viz. Alternanthera spp* Forssk., *Croton banplandianum*, *Calyptocarpus vialis*, *Hyptes suaveolens*, *Lantana camara*, *Parthenium hysterophorus*, *Senna uniflora* and *Eichhornia crassipes etc.* Since invasive alien species are a great threat to native biodiversity, they should be monitored carefully to avoid imposing high cost to agriculture and ecosystem.

P - 10

E-module on weed seed identification

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Correct identification of weeds is the first step for an effective integrated weed management programme. Acquaintance with the plant morphological features, such as leaf and stem shape, flower type and colour, and the presence of hairs make identification relatively easy compared with relying on seed physical characteristics. Identification of weed seeds with the support of color illustrations and description of seed morphological features is an easy method of weed seed identification. However, identification of weeds/weed seeds by reference manual is time consuming besides adding difficulties in carrying and maintaining the books. The e-module on weed/weed seed identification will be helpful for easy retrieval of the information. Seed images, along with weed images, are grouped by their scientific name and common name and also the family to which they belong. Seeds size, shape, color and texture characteristics are described. The purpose of this e-module is to assist the researchers, students and those who attempt to identify weeds by their seed morphological characteristics.

P - 11

Weed seed bank and dynamics as affected by different tillage and plating management in rice –wheat system

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Weeds have a greater genetic diversity than rice crop. Consequently, if a resource (light, water, nutrients or carbon dioxide) changes within the environment, it is more likely that weeds will show a greater growth and reproductive response. In central part (Madhya Pradesh and Chhattisgarh) of India rice grown in variable climatic condition. The field experiment were carried out at Krishi Nagar Research Farm, JNKVV, Jabalpur, (M.P.) continuing 2 years 2007-08 to 2008-09. Sixteen treatments consisted with 4 tillage and planting management for both crop components under rice-wheat system were tested in strip plot design with 3 replications. Tillage and sowing methods were P_1- direct drilling in dry field, P_2-direct seeding of sprouted seeds through drum seeder in puddled field, P_3-manual transplanting and P_4-transplanting through self propelled transplanter (SPT) for rice cv. Kranti and T_1-conventional tillage sowing, T_2-zero till sowing, T_3 -strip till sowing and T_4-bed planting for wheat. Soil samples of 0.5 kg by weight were taken with the help of core auger at 3 soil depths *viz.*, 0-5, 5-10 and 10-15 cm from each treatment plot before sowing of both crop components under a fixed rice-wheat system. The existing seed bed conditions before sowing of each crop was taken into consideration to decide the time of sampling. Then collected soil samples were well labelled with tags and allowed to sun-drying. After proper sun-drying, these samples were grounded into fine particles with help of mortar and pistal. Then these samples spread on the peteriplates separately in almost homogeneous and uniform layer. The peteriplates were marked for each treatment separately with glass pencil .After this, regular watering was done upto 15 days with the help of water cane uniformly in all peteriplates. The numbers of germinated weed seedlings were counted under each treatment at 15 days after regular watering. Finally, weed seed counts/kg soil was worked out for each treatment. On top layer of soil (0-5 cm) ,mean weed seed counts/kg soil was maximum (55.2) in DSR-P_1 among all tillage and sowing methods , which reduced as 38.7 ,37.4 and 35.6 weed seeds/kg soil in P_2,P_3 and P_4 ,respectively . But variation between the latter three tillage and sowing methods were not significant. On the middle (5-10cm) and lower (10-15 cm) layers of soil, the mean weed seed counts was significantly minimum as 32.6 and 23.2 weed seeds/kg soil, respectively under P_1 among all tillage and sowing methods of rice. The mean number of weed seeds / kg of soil before sowing of rice as affected by different sowing methods of preceding wheat (T_1, T_2, T_3 and T_4) ranged from 40.9 to 42.3, 39.2 to 40.2 and 27.2 to 27.4 at top, middle and lower layers of soil, respectively, but variations did not reach to the level of significance . However, it is remarkable to note that zero till sown wheat (T_2) had numerically maximum weed seed counts/kg soil at each layer of soil.

P - 12 Effect of long term application of herbicides on soil properties

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Butachlor, pretilachlor and 2,4-D are the three major herbicides widely used by farmers for weed control in wet seeded rice. These herbicides are applied at the rate of 1.25, 0.45 and 1.00 kg/ha respectively at 6-9, 3-5 and 20 days after sowing. Soil characteristics affect the herbicide use efficiency and crop yields. Little information is available on the impact of long term application of herbicides on soil characters. Soil samples(0-15 cm depth) were taken from the "Long term herbicide trial in rice- rice system" which is being conducted with six treatments since 2001 under AICRP on weed Control, KAU Centre. The treatments were (i) hand weeded control (100% NPK through fertilizer): (ii) continuous application of butachlor +2,4- D (100% NPK through fertilizer): (iii) butachlor alternated with pretilachlor between seasons +2,4-D (100% NPK through fertilizer) :(iv) butachlor alternated with pretilachlor between seasons +2,4-D (75% NPK+25% N through FYM: (v) butachlor alternated with pretilachlor between years +2,4-D (100% NPK through fertilizer):(vi) butachlor alternated with pretilachlor between years +2,4-D (75% NPK+25% N through FYM). Soil sampling was done in the month of March every year (about at two months after the harvest of second crop) so as to reduce the temporary fluctuations in soil properties due to cropping. Differences in soil properties *viz.,* organic carbon, pH and available P and K due to the different treatments were calculated and expressed as % change over the years (2002-2011). Effect of the treatments made during last 10 years (20 crop seasons) is presented here. In the case of pH and organic carbon, the per cent change over the years was in the range of 0 to -10.7 and 2.5 to -23.0, respectively. Greater and positive changes were observed in the case of available P and K, the range being +52.88 to + 141.76 and +47.16 to+114.27, respectively. Both hand weeding and the herbicide treatments recorded no considerable changes in pH and organic carbon. In the case of available P, the hand weeding treatment and the herbicide application without FYM recorded lesser changes. Application of FYM resulted in significant increase (105 (T4) to 141% (T6)) in the available P. All the herbicide treatments resulted in significant increase in the available K content of the soil (96 to 118%). The study showed that herbicide application do not have any deleterious effect on soil quality. Instead, considerable positive effects were observed on available P and available K.

P - 13 Evaluation of residues of butachlor 50 EC herbicide applied to rice–rice system

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A field experiment was conducted to evaluate the persistence of butachlor 50 EC herbicide applied to paddy crop in a long term herbicidal trial in rice-rice cropping system at Agricultural Research Station, Kathalagere, Davanagere District. The experiment consisted of six treatments i.e., three weed management practices consisting of butachlor 50 EC at 0.75 kg/ha + 2,4-D EE 38 EC at 0.4 kg/ha applied in sequence both during *kharif* and summer and same treatment applied in *kharif* followed by pretilachlor 50 EC at 0.75 kg/ha during summer and twice hand weeding at 20 and 45 DAP and two sources of soil fertility replicated four times in a RCBD design. The soil and water samples were collected at periodic intervals and residue estimation was carried out in grain, straw, soil and underground water (ppm) during summer and *kharif* 2011. During summer, at the time of harvest the residue of butachlor were below the detectable level of 0.01 ppm in soil, grain and straw samples (118 days after herbicide application) at recommended level of application. Same trend was noticed during *kharif*. At the time of harvest the residue of butachlor were below the detectable level of 0.001 ppm. in soil, grain and straw samples (113 days after herbicide application).

P - 14 Influence of organic matter sources on adsorption of butachlor and pretilachlor in laterite soil

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Adsorption is a major factor of determining the fate and persistence of herbicide in soil. In laterite soil, leaching loss of herbicides is more because of its low capacity for retaining these chemicals. Addition of the organic matter is an important measure to improve herbicidal efficiency, as it can greatly increase the amount of dissolved organic carbon (DOC) in solution which affects the sorption and leaching of pesticides. A pot culture study with rice as test crop grown under submerged condition was conducted to quantify the adsorption of herbicides on soil. The treatments consisted of two herbicides (butachlor 1.25 kg/ha and pretilachlor 0.45 kg/ha) which were sprayed at six days after sowing. Three carbon sources *viz.,* farmyard manure (FYM), vermicompost and soil alone were applied in the pots before sowing. The soil samples were taken at one day, one week, two weeks and four weeks after herbicide application and after harvest. Results indicated that there was significant variation in the quantity of herbicides adsorbed by soil in the different treatments. Higher concentration of butachlor compared to pretilachlor in the soil at one day after application was due to the differences in their rate of application. Initial adsorption (one day after spraying) of butachlor as well as pretilachlor was highest in vermicompost treatment. The treatment with FYM recorded higher DOC than that of vermicompost which would have resulted in an increase in the mobility of chemicals and thereby reducing the quantity adsorbed by soil. Persistence of butachlor and pretilachlor in terms of half life was highest under FYM treatment (17.0 and 18.5 days for butachlor and pretilachlor, respectively).

P - 15 Residual effect of sulfentrazone applied to planted sugarcane on succeeding crops

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The field experiments were conducted during June-July and March-April of 2010 and 2011 with fifteen treatments. The treatments consists of pre emergence application of sulfentrazone at 720, 840, 960, 1080, 1200, 1320, 2400 g/ha and pre plant incorporation of sulfentrazone at 1080, 1200, 1320, 2400 g/ha, PE-atrazine 1250 g/ha, POE -2,4-DEE 1200 g/ha, HW on 30 DAP and control. The experiments were laid out in a randomized block design with three replications. it was found that the pre plant incorporation of sulfentrazone at 1200 g/ha recorded lower weed density, weed dry weight, higher weed control efficiency and higher cane and sugar yield which was at par with pre emergence of sulfentrazone at 1200 g/ha. To study the residual effect of herbicides applied to sugarcane, the succeeding crops such as, maize, sunflower and cowpea were raised without disturbing the layout of sugarcane experiment. Total weed density in the succeeding crops significantly altered due to the weed management practices followed in preceding herbicide. In succeeding crops like maize, sunflower and cowpea, lower density of total weed was recorded with sulfentrazone at 1200 g/ha which was on par with pre emergence application of sulfentrazone at 1200 g/ha. Germination percentage, dry matter production and yield of the succeeding crops *viz.,* maize, sunflower and cowpea were not affected due to the application of sulfentrazone to the preceding crop of herbicide. Among the weed management treatments, there was no significant variation in germination percent, dry matter production and yield of the succeeding crops, given to preceding sugarcane in both the years of study.

P - 16 Best management strategies for preventing herbicide resistance evolution: experiences from the midsouth united states

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Herbicide resistance in arable weed communities has been a growing issue worldwide. Although the majority of the existing resistant weeds have been documented in the industrialized nations, there is an increasing risk for resistance evolution in the developing world. This is particularly true for countries like India where rapid industrialization has resulted in the inevitable shortage of agricultural labor, forcing the growers to depend more and more on herbicides as the primary tool for weed control in their production systems. Inadequate herbicide stewardship measures coupled with a lack of awareness has already led to the evolution of herbicide-resistant weeds in some production systems. For instance, herbicide resistance has been a persisting issue in the rice-wheat systems of north India. In areas where herbicide usage is high, growers need to be proactive and employ appropriate strategies for preventing resistance evolution. In this respect, experiences in preventing or managing herbicide resistance elsewhere will be highly valuable for developing such measures. The presentation focuses on our learning's with herbicide-resistant weeds in the Midsouth U.S. crop production systems. A number of best management practices have been identified, using herbicide resistance simulation models, for preventing herbicide resistance evolution. The discussion particularly focuses on tactics that are applicable across a range of crop production systems in India.

P - 17 Effect of glyphosate K salt applied in preceding transgenic stacked cotton hybrids on succeeding crops

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Biological modifications can be made through gene transfer or by selection of genetic mutations using seed or tissue-culture screens. Herbicide-resistant crops (HRC's) developed with these technologies quickly had an important impact on agriculture. In this view, the field experiments were conducted to study the carry over effect of glyphosate K salt applied in preceding transgenic stacked cotton hybrids (Mon 15985 x Mon 88913) in succeeding sunflower, soybean and pearl millet in the experimental site of Tamil Nadu Agricultural University, Coimbatore during winter season of 2009-10 and 2010-11. Glyphosate was applied as early POE application on 25 and 65 DAS at 900, 1350, 1800, 2700, 3600 and 5400g/ha in MRC 7347 BG-II RRF test hybrid. These treatments were compared with hand weeding on 15 and 30 DAS and unweeded control. Succeeding crops like sunflower, soybean and pearl millet were sown immediately after the harvest of herbicide tolerant transgenic cotton. Observations like germination percentage, visual phytotoxicity, plant height, total weed density, dry matter production and yield were recorded. The result showed that, germination percentage and vigour of residual crops were not significantly influenced by weed control treatments imposed on the previous cotton crop and also there was no crop phytotoxicity in residual crops observed with different doses of glyphosate and other weed control treatments applied in transgenic cotton hybrid. Total weed density in the succeeding crops significantly altered due to the weed management practices. During both the seasons, in the succeeding crops like sunflower, soybean and pearl millet, lower density of total weeds was recorded with glyphosate at 5400, 3600 and 2700 g/ha compared to other treatments and also higher density of total weeds was observed under unweeded check. There was no significant influence on plant height, dry matter and grain yield of residual crops by post emergence application of glyphosate in preceding transgenic cotton hybrid.

P -18

Has little seed canary grass evolved cross resistance to clodinafop and sulfosulfuron in Punjab?

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Little seed canary grass (*Phalaris minor*Retz.) is the dominant grassy weed of wheat especially in rice-wheat cropping system which dominates inceptisols of northern India. It developed resistance to isoproturon herbicide in early 90's. Alternate herbicides *viz.,* clodinafop, sulfosulfuron and fenoxaprop were recommended for its control and were widely adopted by the state farmers. Complaints of poor efficacy of these alternate herbicides started appearing from 2008-09. In this context, performance of alternate herbicides was evaluated through farmers' field survey conducted at 73 farmers' field in six districts *viz.,* Patiala, Fatehgarh Sahib, Ludhiana, Moga, Jalandhar and Ropar in Punjab. The survey indicated that clodinafop and sulfosulfuron are widely used by the farmers; clodinafop being safe for succeeding crop is preferred over sulfosulfuron. The farmers used to apply field rates of these herbicides till 2008-09 and were getting effective control of *P. minor* (>85%). During 2009-10, clodinafop started showing signs of reduced efficacy and >30% farmers used 1.5 times of field dose and control was still poor (<65%); few farmers (<10%) used 2 times the field dose with little success. The situation become alarming in 2010-11 when clodinafop at field dose did not show any toxic effect on *P minor* and the farmers (<50%) used 2 times and <30% used 3 times or higher dose of clodinafop alone/ tank mix of clodinafop + sulfosulfuron/both herbicides in sequence and control was still poor (<60%); re-growth recorded particularly in Patiala, Fatehgarh Sahib, Ludhiana and Moga districts. Few farmers (<8%) used higher (1.5 times) dose of sulfosulfuron in Patiala and Moga districts only. Sulfosulfuron efficacy also showed declining trend (<60%) during 2010-11; reduced efficacy was more prevalent in fields having history of continuous use of sulfosulfuron but poor efficacy of clodinafop was even recorded in field having continuous use of sulfosulfuron. The spray methodology adopted by the farmers was better than they were using in the previous years hence it cannot be related to the reduced herbicide efficacy. The survey results pointed towards the evolution of cross resistance in *P. minor* to clodinafop to a large extent and that sulfosulfuron was likely to meet the same fate in the near future. The situation is likely to be worse in the coming years. Proper and regular monitoring of all the existing herbicides is desirable before the situation comes out of control at farmers' field.

P -19

Persistence of pretilachlor in soil and food chain under direct seeded rice

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A field experiment was conducted at Central Research Station OUAT, Bhubaneswar, Orissa to study the persistence of pretilachlor in soil and food chain under direct seeded rice during *kharif*, 2011 in sandy clay loam soil- low in N and K, medium in P. Pretilachlor was applied x (1 kg/ha), 2x (2.0 kg/ha) to the soil and its persistence was analysed sampling soil at 0 10 20 30 45 60 90 days and Harvest from a depth of 0-15 cm, grain and straw using gas chromatograph (ECD) with a detectable limit of 0.001 mg/kg in temperature conditions-column 210^{0}C, injector 230^{0}C, detector 250^{0}C-carrier gas nitrogen and flow rate 40ml/min. The residues of pretilachlor in soils when applied at recommended dose of 1.0 kg/ha were recorded up to 45 days and at 2. 0 kg/ ha were observed up to 60 days. In post harvest soil, grain and straw samples, the residues were below detectable limit of 0.001ppm.

P -20 Study of persistence of herbicides in rice rhizosphere under different tillage systems

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Rice – wheat cropping system was rotated for four consecutive years with different tillage systems vis-à-vis weed control practices and in fifth year (2009) studies were conducted to evaluate the period of persistence of applied herbicides in rice rhizosphere under different tillage systems in terms of their effect on microbiological and biochemical properties of soil. Four types of tillage system were evaluated and put in main plots *viz.,* (1) conventional-conventional (ii) conventional–zero (iii) zero-conventional and (iv) zero-zero tillage system. Among weed control practices performance of hand weeding and recommended herbicidal application was tested, comparing with a weedy check and put in sub plots. As recommended herbicides for *kharif* rice butachlor was sprayed in pre emergence and fenoxaprop-p-ethyl and ethoxysulfuron in post emergence stages of crop 1.5 kg, 56.25 g and 15 g/ha, respectively. The pre emergence and post emergence herbicides were applied at 3 and 20 days after sowing of the crop. The treatments were replicated thrice under split plot design. Soil from rhizosphere was collected from 7.5-15.0 cm. The results revealed that quantity of soil enzymes like phosphatase and dehydrogenase changed significantly due to different tillage systems at 30 and 50 days after sowing. However, the effect of the systems persisted up to harvest in terms of their effect on dehydrogenase activity. The enzymes' activities were found maximum under conventional-conventional and minimum under zero-zero tillage system During microbial population study the population of fungus and bacteria was found maximum under conventional-conventional tillage system and minimum under zero-zero tillage system. The use of recommended herbicides application significantly inhibited the enzymes' activity, basal soil respiration rate, microbial population and microbial biomass carbon status of rhizosphere soil of rice. The weedy check condition improved the bio-chemical and microbiological properties of the soil during active growth stages (30 and 50 DAS) of the crop. The data on microbial population & microbial biomass carbon content also shown the similar trend. It was concluded from the above study that conventional-conventional systems facilitated the growth of microbes in the crop rhizosphere in comparison to three other systems. Among different weed control practices hand weeding practice found better than chemical (herbicidal) control of weeds. However, applied herbicides were completely degraded by reaching to the harvest stage of the crop which indicated that applied herbicides were environmentally safe at the applied rates.

P -21 Characterization of leaching behaviour of oxyfluorfen in soil

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A laboratory experiment was conducted during *kharif*, 2011 to characterize the leaching behaviour of oxyfluorfen. Sandy clay loam soil collected from Central Research Station OUAT, Bhubaneswar was filled in the columns of PVC pipes 60 cm long and 10 cm internal dia cut vertically into two and joined together by adhesive tapes with lower ends covered with muslin cloth. Water was applied to precondition the soil. Calculated quantity of oxyfluorfen i.e the recommended dose (0.15 kg/ha-x) and double the recommendation (0.30 kg/ha-2x) were applied to the column. Water was added everyday to the columns and each column was replicated twice. After 15 days the soil columns were split vertically and dissected into 5 cm increments. Each section was allowed to air dry, and the soil samples from different layers were analyzed for oxyfluorfen residues by GLC. The residues decreased significantly with depth. Residues could be detected up to 15 cm depth irrespective of concentrations. The leachate collected at 60 cm depth were analyzed for residue and no residues could be detected there.

P -22 Survey on efficacy of herbicides against resistant population of *P. minor* in wheat at farmers' fields in Haryana

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During 1997, clodinafop, fenoxaprop and sulfosulfuron were recommended for the control of *P. minor* in wheat. After 10-12 years of their use, complaints of poor or no efficacy of these herbicides particularly clodinafop are being received from different districts of Haryana state. Keeping in view of alarming situation of poor control of *P.minor* in various parts of Haryana, present survey was conducted by dividing state in three zones during *rabi* 2011-12 in Kaithal, Karnal, Fatehabad, Jind, Kurukshetra (Pehowa), Ambala (Naggal block), Panipat districts (zone 1), Yamuna Nagar, Ambala (N.Garh and Barara tehsils) and Kurukshetra (Shahbad Markanda tehsil) districts (zone 2), Fatehabad (Ratia tehsil) and Sirsa districts (zone 3) of state. Complaints of poor efficacy were reported mainly from zone 1, where farmers are using alternate herbicides continuously since the last 12 years. In all 163 farmers were interviewed in all three zones. In zone 1, during 2010-11 out of 75 farmers, only 3 farmers (4%) used recommended dose of clodinafop with 22% control of *P. minor* because of poor efficacy achieved last year whereas in zone 2 even 28% farmers used ¾ th dose of clodinafop with more than 90% control. In zone 1, 25% farmers used double of recommended dose of clodinafop with only 36% control of *P. minor*. Forty five per cent farmers reported using clodinafop continuously since 1998. Remaining 55% followed herbicide rotation with sulfosulfuron, fenoxaprop but frequency of clodinafop use was more in these years. Choice for clodinafop is decreasing in this zone as shown by clodinafop use from 2008 to 2010. In 2008, 84% farmers used recommended dose of clodinafop and achieved 73% control. In 2009, only 48 farmers used recommended dose of this herbicide but achieved only 47% control where as only 4% farmers used recommended dose of clodinafop in 2010 with merely 22% control. But in zone 2, efficacy of clodinafop and number of users of clodinafop did not decrease and is same as in year 2008 and 2009. None of the farmer used double to recommended dose of clodinafop in this zone. All herbicides gave more than 90% control of *P. minor*. Even in zone 1, use of sulfonylurea herbicides like meso+iodosulfuron (Atlantis), SSN+MSM (R.M) and sulfosulfuron proved very effective against *P. minor* with 80-90% control, indicating cross-resistance against clodinafop only. In zone 3, situation is very comfortable as *P. minor* is less subjected to herbicides due to crop rotation. In this zone as 72% farmers used clodinafop this year whereas only 26% farmers, who are not following crop rotation, have to go for sequential application or double dose of clodinafop with only 41–75% control. Based on the observations from farmers' interviews and experiments conducted at farmers fields and bioassay studies, it seems that *P. minor* has developed resistance against clodinafop herbicide in Kaithal, Karnal, Jind, Panipat and parts of Fatehabad, Ambala and Kurukshetra districts of Haryana.

P -23 Studies on residual effect of herbicides applied in rice on succeeding wheat crop

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Field trials were laid out during *rabi* 2009 and 2010 in a randomized block design with four replications at Agronomy Research Farm as well as Weed Science Laboratory of Department of Agronomy, NDUAT, Kumarganj, Faizabad. The application of almix 6 g and 12 g/ha, pretilachlor 0.5 kg and 1.0 kg/ha and oxadiargyl 0.1 kg and 0.2 kg/ha applied at 7 DAT in rice did not show their significant effect on density (m^2), dry weight (gm^2) of weeds and grain yield of rice (q/ha). Thus, the results revealed that almix 6 and 12 g/ha, pretilachlor 0.5 and 1.0 kg/ha and oxadiargyl 0.1 and 0.2 kg/ha at 7 DAT applied in rice to control the weeds did not showed their residual effects on weed density, weed dry weight and wheat yield significantly.

P -24 Retention and movement of oxyfluorfen in different soils under compacted soil column

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Laboratory soil column experiment was conducted to study the leaching behaviour of oxyfluorfen in different soils using PVC pipes. One day before the herbicide application columns were pre treated with 500 ml distilled water. The treatments imposed were oxyfluorfen 200 g recommended (x) and 400 g/ha double the recommended dose (2 x) and control (no herbicide). Sufficient quantity of water was added everyday to govern the movement of herbicides. Each column was replicated thrice. At the end of experimental period (7 days) column was sectioned into different depths *viz.,* 0-5, 5-15, 15-30, 30-45 and 45-60 cm. The leachates were collected from all the treatments on 5th and 7th day. Soil samples and leachates were analyzed for oxyfluorfen residue using gas chromatograph equipped with ECD detector. Results showed that the oxyfluorfen residue decreased with increase in soil depth and residue was present up to 60 cm depth under both the levels of application with irrespective of soil types. Increased dose of application enrich the soil with that herbicide molecule besides transporting considerable quantity to lower depth also. After 7 days, 7-10, 13-16 and 17-64 per cent of the applied quantity of oxyfluorfen remained in the soil across different depths respectively in silty clay loam, peat and clayey soils and the per cent retention is more in double the recommended dose. Retention of oxyfluorfen is in the order of clayey > peat and silty clay loam soils. While more than 17 per cent of the applied oxyfluorfen retained in top layer of 0-5 cm depth in clayey soil, only 4.2 and 3.7 per cent was retained in silty clay loam and peat soils, respectively. The residue of oxyfluorfen was also detected in the leachates collected at 60 cm depth. Leaching of oxyfluorfen in different soils were in the order of peat soil > silty clay loam > clayey soil.

P -25 Residual effect of oxyfluorfen applied to *kharif* groundnut on succeeding *rabi* crops

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Field investigation were carried out at the Agricultural Research Station, Bhavanisagar of Tamil Nadu Agricultural University, during *kharif* season of 2009 and 2010 to evaluate the new formulation of oxyfluorfen (23.5% EC) on weed control in groundnut and their residual effect on succeeding crops. Based on two years field experimentation, it was found that pre-emergence application of oxyfluorfen (23.5% EC) at 400 g/ha gave significantly lower total weed density and higher weed control efficiency at all the intervals. Application of new formulation of oxyfluorfen (23.5% EC) at 250 g/ha as pre-emergence herbicide can keep the weed density and dry weight below the economic threshold level and increased the growth and yield attributes significantly over unweeded control in groundnut. Uncontrolled weeds reduced the pod yield upto 55-59%. After harvesting of the groundnut crop to know the residual effect of herbicides, without disturbing the layout of each plot was manually prepared for sowing of succeeding crops *viz.,* sunflower and pearl millet during *rabi* season. Results revealed that germination of succeeding sunflower and pearl millet recorded at 10 DAS was not significantly affected by residual effect of herbicide applied to irrigated groundnut. Though, the plant stand of sunflower ranged from 84 to 89 per cent and pearl millet from 87 to 94 per cent under all the treatments at 10 DAS. Further, plant height and dry weight of plants recorded at 30, 60 and 90 DAS were also unaffected due to residual effect of different doses of oxyfluorfen applied in groundnut. Yield of sunflower and pearl millet showed no distinct variation due to different dose of oxyfluorfen. It might be inferred that new formulation of oxyfluorfen with different doses could be very effective against most of the broad leaved and grassy weeds in groundnut. But residual toxicity of oxyfluorfen can be ruled out even on sensitive crops such as sunflower and pearl millet in rotation.

P -26 Leaching behaviour of butachlor and pretilachlor in soils as affected by texture

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The fate of herbicide in soil is influenced by its adsorption, degradation and leaching through the soil profile. Soil parameters like organic matter content, soil type, water transmission characteristics influence the leaching behaviour of a soil. Butachlor and pretilachlor are used as pre-emergence herbicides in rice crop, both under dry seeding and transplanted situations. In high rainfall areas, like Assam, with shallow water table leaching may be an important factor contributing to the contamination of groundwater by herbicide residue. A laboratory experiment was conducted with air dried soils, passed through 2 mm sieve, of sandy loam (organic carbon 7.6 g/kg, bulk density 1.48 Mg/m^3 in o-30 cm and 1.58 Mg/m^3 in 0-30 cm depth) and sandy clay loam (organic carbon 8.5 g/kg, bulk density 1.36 Mg/m^3 in 0-30 cm and 1.52 Mg/m^3 in o-30 cm depth) textures. PVC pipe of 10 cm diameter and 5 cm length, fixed from outside with adhesive tape was filled with respective soils in sequential order of soil depth into 60 cm column in duplicate. The soil at the bottom of the column was held with a muslin cloth. The recommended and double the recommended doses of herbicides butachlor (1.0 kg/ha and 2.0 kg/ha) and pretilachlor (0.75 kg/ha and 1.5 kg/ha) were applied and water was leached through the column at rates equivalent to the soil permeability. Soil column was dismantled after leaching of one pore volume of water. The leachate was collected at the bottom of the column and soil samples were analysed for herbicide residue. Highest residue was detected in the 0-5 cm layer of soil irrespective of herbicide and doses applied, which decreased with depth. The leaching of herbicide at recommended dose was observed up to 30 cm in case of butachlor (sandy loam soil) and 25 cm with pretilachlor (sandy clay loam soil), while at double recommended dose herbicides leached to a depth of 30 cm in sandy loam soil for butachlor and sandy clay loam soil in pretilachlor. The maximum herbicide residue concentration of 0.262 ppm was detected for butachlor and 0.207 ppm in pretilachlor, both in sandy clay loam soil and with double recommended doses.

P -27 Herbicide use pattern and 2,4-D residue status in groundwater and natural water resources in some tea growing areas of Assam

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The major consumption of herbicides in Assam is confined to tea crop, which covers approximately an area of more than 0.2 m ha. The peak crop productivity from May to September coincides with monsoon rain and consequently profuse growth in weeds. Accordingly, several applications of herbicides are required for achieving optimum yield. Besides, the use of herbicide in tea has been in practice for over three decades in this region. The present study was thus undertaken to have an account of the use pattern and residue status of the herbicides in some tea growing areas of the state. During the period from March 2005 to July 2007, 42 water samples were collected covering 11 districts of the state, and analysed for 2,4-D residue in a GC (Thermofisher, India GC 1000) following standard procedures. Information pertinent to herbicides and their application dose and frequency were collected from the stakeholders. All the gardens under survey reported use of same herbicides, i.e. 2,4-D, glyphosate and paraquat, except one tea garden in Sivasagar district which used oxyfluorfen as additional herbicide. The intensity of herbicide application, in general, was 2 to 3 rounds of spray in a year and was followed by 50% of the gardens. About 43% adopted 4 to 5 applications during the year while the rest have a practice of application of more than 5 applications per year. Residue of 2,4-D was detected in 4 out of 42 samples, which ranged from 0.13 to 0.37 ppm, while in the rest it was found below detectable level (0.1 ppm). All the four water samples, with detectable levels of 2,4-D residue, were from surface water resources adjacent to tea crop and the contamination might have resulted from run off.

P -28 Effect of alternate wetting-drying of soil on the efficacy and dissipation of butachlor, pretilachlor and pendimethalin

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Degradation of applied herbicide and consequently its persistence in a soil is an important aspect of chemical weed control measure. In one hand it should persist in the soil for managing weeds in the existing crop, on the other hand longer persistence may be a problem for the succeeding crop to be grown the field. Under field condition, sometimes soil remain continuously moist for a sufficiently long period of time, while at times it passes trough alternate spell of drying and subsequent rewetting due to irrigation or rainfall. In view of this, an experiment was conducted under laboratory condition to study the persistence of butachlor, pretilachlor and pendimethalin in soil under such varying soil moisture conditions and its implication on the growth of *Echinochloa colona*. Recommended doses of butachlor, pretilachlor and pendimethalin were sprayed to the soil taken in a series of small pots. The pots were randomly divided into two sets, namely, Set-A and Set-B. Set-A was watered everyday to keep the soil at field capacity (FC) level, while the soil of Set-B was allowed to pass through alternate wetting-drying (WD) cycle and watered to FC level at 7 days interval of time. All the pots were kept under laboratory condition and 6 pots from each set were taken out randomly at 7, 15, 25, 35 and 45 DAA of herbicide. Out of six, 3 pots were analysed for herbicide residue content, and in the remaining 3 pots *E. colona* was sown and observation on its germination and shoot length were recorded at 5 DAS. The dissipation of pendimethalin was relatively faster under continuous FC moisture regime than in the soil passed through alternate wetting drying resulting in a relatively lower half-life value of 18.1 days in former compared to 29.9 days at later moisture regime. Relative growth of *E. colona* sown after 45 days of pendimethalin application was 84% in the soil that received alternate wetting-drying treatment, whereas its 100% growth was recorded when the soil was kept at FC moisture level. This indicated relatively longer persistence of pendimethalin under alternate wetting-drying condition. Similar observations were recorded in case of pretilachlor and butachlor.

P -29 Evaluation of herbicide resistant transgenic maize hybrids containing stacked events

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Maize is the third most important crop in the world agricultural economy after wheat and rice. The major yield reducing factors for corn cultivation are weeds and insects. Yield losses due to weeds varied from 28 to 29%. Transgenic corn hybrids with stacked event, (TC1507 X NK603) having both insect protection and herbicide tolerant traits provide protection to the crop against target inset pests and weeds. Field experiment was carried out during *kharif,* 2010 at experimental site of Tamil Nadu Agricultural University, Coimbatore and the experiment was laid out in randomized block design with replicated thrice. The treatments consisted of two transgenic hybrids (30V92 and 30B11 HR) resistant to glyphosate were tried with two different doses of POE of glyphosate at 900 and 1800 g/ha and these were compared with pre-emergence application of atrazine at 0.5 kg/ha followed by hand weeding on 40 DAS in non-transgenic maize hybrids like 30V92, 30B11, BIO 9681 (national check) and COHM5 (local check). From the study it was concluded that, early POE application of glyphosate at 1800 g/ha recorded lower weed density, higher weed control efficiency in transgenic maize hybrid compared with other treatments. Higher grain yield was recorded with POE application of glyphosate at 1800 g/ha in transgenic stacked maize hybrid of 30V92HR.

P -30

Biosafety assessment of transgenic stacked corn hybrids (MON 8903 x NK603)

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Corn now ranks as the third most important food grain crop in India. Its area has slowly expanded over the past few years to about 6.2 million ha (3.4% of the gross cropped area). Major constraints in achieving the desired potential of corn are biotic factors as weeds, rats and insect pests which reduced the maize production levels by more than 50%. Keeping in view the above facts to achieve the desired potential of corn, an experiment was carried out at DWSR for the consecutive two years during *kharif* 2010 and 2011 to study the bio-efficacy and residual study of glyphosate in transgenic corn (MON 89034X NK 603). Two transgenic corn hybrid Hishell and 900M Gold, resistant to Glyphosate as well as to stem borer (*Chilo partelus*) and cob borer (*Helicoverpa* sp.), were tested and compared with its non-transgenic counterpart Proagro-4640 and HQPM-1. There was no natural infestation of borers in transgenic and conventional hybrids. Hence *Chilo partelus* and *Helicoverpa* sp. was introduced artificially from ICRISAT, Hyderabad for artificial inoculation with a view to assess the resistance against stem borer incidence. Although, inoculation was done late but there were symptoms of injury and infestation of the pest in the treatments which showed severe attack of the pest on the crop. The observations on per cent infestation and mean leaf injury score were taken after 15 days of inoculation.

Major weeds, present in the experimental field were *Echinochloa colona, Cyperus iria, Corchorus* sp.*, Phyllanthus niruri, Dinebra* sp., *Physalis minima, Commelina benghalensis, Alternanthera sessilis etc*. and major insects recorded were coccinalid, spider, syrphids, pollinator, aphids *etc*. Results revealed 100% weed control in Hishell and 900M Gold transgenic hybrids receiving K salt of Glyphosate. Per cent infestation after 15 DAS showed complete absence of stem borer infestation and leaf injury score (LIS) 1 in all the transgenic entries of Hishell and 900M Gold. Where as, in all other conventional entries, stem bore infestation was observed and the LIS was more than 1. There was about 31 to 43 per cent infestation in conventional 900 Gold while in local check conventional, it was 100 per cent (HQPM-1) followed by national check (Proagro 4640). Tunnel length taken at the harvest time after tearing the stems also revealed highest tunnel length in national check and local check which correlates the highest infestation per cent of stem borer after artificial inoculation. No infestation of *Helicoverpa* in all transgenic entries of Hishell and 900M Gold was observed. Where as, in the remaining non-transgenic corn treatments, significantly higher infestation was observed as compared to transgenic hybrids. Significantly 36-71 per cent infestation was observed in all the non-transgenic lines which showed that transgenic entries are resistance to *Helicoverva* spp. also. In case of yield parameters, maximum total cob weight was recorded in Hishell and 900M Gold stack corn treated at 900, 1800 and 3600 g/ha levels of glyphosate and was found significantly higher than rest of the treatments. Fodder yield/plot of 900M Gold stalk at all the level of glyphosate was significantly higher than rest of the treatments. Although the fodder yields did vary significantly amongst transgenic hybrids. Hishell and 900 M Gold transgenic hybrids performed better with regard to grain yield ranging between 6-8 t/ha which was approximately three times higher than the average yield of maize crop per hectare *i.e*. 2.30 t/ha.

P -31 Evaluation of residues of pyrazosulfuron ethyl 10 wp herbicide applied to paddy

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A field experiment was conducted to evaluate the persistence of pyrazosulfuron ethyl 10 WP herbicide applied at 25 g/ha (x Dose) and 50 g / ha (2x Dose) to paddy crop at Agricultural Research Station, Kathalagere, Davanagere District. The experiment consisted of six treatments i.e., pyrazosulfuron ethyl 10 WP applied at 25 g/ha and 50 g/ha with and without farm yard manure in comparison to hand weeding and unweeded control replicated four times in a RCBD design. The soil and water samples were collected at periodic intervals and residue estimation was carried out in grain, straw, soil and underground water (ppm) during *kharif* 2011. The results showed that there was no detectable residue of pyrazosulfuron ethyl 10 WP both at 25g/ha (recommended dose) and 50g/ha (double the recommended dose) at different intervals and at harvesting stage (120 days after planting) in soil, paddy grain and straw. The residue of pyrazosulfuron ethyl 10 WP were below detectable level at 45th day after application of herbicide in underground water in rice cultivated field at both 25 and 50g/ha. In the soil, pyrazosulfuron ethyl degraded fast at both 25 and 50g/ha. The persistence pattern indicated that residue of pyrazosulfuron ethyl was not observed after 45 days at 25g/ha and also at 50g/ha.

P -32 Persistence of herbicides applied to soybean and its effect on soil microbial population

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A field experiment in soybean was conducted during the *kharif* season of 2010 and 2011 at research farm RVSKVV, College of Agriculture, Gwalior. Treatments consisted of recommended (1.0 kg/ha) and double the recommended (2.0 kg/ha) doses of pendimethalin (PE), recommended (9 g/ha) and double the recommended (18 g/ha) doses of chlorimuron ethyl (PoE) along with weedy check and weed free (two hand weeding at 30 and 45 days after sowing) were tested in a randomized block design having four replications. Soil samples (0-15 cm depth) from each plot were collected immediately after application and then at 15 days interval up to 60 days and after harvest of crop for persistance studies. Persistence of herbicides was measured by bioassay technique using maize as indicator plant. Observations on plant height, fresh weight and dry weight of maize were recorded 25 days after sowing. Soil samples collected after 0,7,15 and 30 days after application of herbicides and at harvest were collected for determination of microbial population. Serial dilution plate technique was applied using the rose bengal agar medium for fungi, Ken-Knight and Mundal's medium for actionomytes and Thrornton medium for bacteria. Plant height of maize was significantly reduced up to 60 days by pendamethalin 2.0 kg/ha and both the doses of chlorimuron ethyl while pendimethalin 1.0 kg/ha could reduce the plant height up to 45 days only. Fresh weight of maize plant was significantly reduced up to 45 days by double the recommended doses of both the herbicides i.e. 2.0 kg/ha pendimethalin and 18 g/ha chlorimuron ethyl. Both the herbicides applied to soybean could not affect the growth of indicator plant in post harvest soil. Results on microbial count reveal that total population of bacteria, actinomycetes and fungi in soil reduced considerably up to 15 days after application of both the herbicides. Pendimethalin 2.0 kg/ha and chlorimuron 18 g/ha showed more suppressive effect on microbial count as compared to their lower doses. However the population was restored after 30 days of application and at harvest.

P -33 Residual effect of pre emergence mixed herbicides in transplanted rice on succeeding crops

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The field experiments were conducted in wetland farm, Tamil Nadu Agricultural University, Coimbatore during *kharif,* 2010 and 2011, to study the residual effect of pre-emergence mixed herbicide on greengram. Based on the two years of experimental result, the pre emergence application pyrazosulfuron ethyl 0.15% + pretilachlor 6% (UPH 309) at 20 kg/ha^{-1} recorded lower weed density, dry weight and higher weed control efficiency at different intervals. The application of pyrazosulfuron ethyl 0.15% + pretilachlor 6% (UPH 309) at 12.5 kg/ha were also recorded lower weed density, dry weight, higher weed control efficiency and grain yield compare to unweeded control. The weedy check resulted in lower weed control efficiency and grain yield. The results revealed that the different weed management practices did not affect the germination percentage of succeeding greengram. The plant height and dry weight of plants recorded at 25, 45 and 65 DAS were also not affected due to the residual effect of different doses of pyrazosulfuron ethyl 0.15% + pretilachlor 6% (UPH 309). There was no significant difference in yield among different treatments. The new formulation of herbicide effectively controlled the weeds. The green gram was sowed after the harvest of transplanted rice did not show any phytotoxicity symptoms. This showed that the succeeding green gram was not affected by the residue of new formulation of pyrazosulfuron ethyl 0.15% + pretilachlor 6% (UPH 309) at different doses.

P -34 Residual effect of imazethapyr applied to *kharif* groundnut on succeeding *rabi* crops

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Field investigations were carried out at the agricultural research station, Bhavanisagar of Tamil Nadu Agricultural University, during *kharif* season of 2009 and 2010 to evaluate the new formulation of early post-emergence (EPOE) herbicide imazethapyr on weed control in groundnut and their residual effect on succeeding crops. Based on two years field experimentation, it was found that the application of imazethapyr 200 g/ha gave significantly lower total weed density and higher weed control efficiency. Application of new formulation of imazethapyr at 100 g/ha can keep the weed density and dry weight below the economic threshold level and increased the growth and yield attributes significantly over control. After harvesting of the groundnut crop to know the residual effect of herbicides, without disturbing the layout, each plot was manually prepared for sowing of succeeding crops in *rabi* season. Results revealed that germination of succeeding sunflower and pearl millet recorded at 10 DAS was not significantly affected by residual effect of herbicide applied to groundnut. Though, the plant stand of sunflower ranged from 85 to 90 per cent and pearl millet from 92 to 97 per cent under all the treatments. Yield of sunflower and pearl millet showed no distinct variation due to different dose of imazethapyr. It may be concluded that new formulation of imazethapyr (10% SL) with different doses could be very effective against most of the broad leaved and grassy weeds in groundnut. Dry matter production and yield of sunflower and pearl millet did not show any variation among the weed control treatments and there was no residual toxicity due to imazethapyr on the succeeding crops.

P -35 Field persistence and dissipation of herbicides under sunflower crop

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Sunflower is one of the vital oil seed crops grown in 0.29 lakh hectares in Tamil Nadu. To control the weeds at early growth stages, either pendimethalin or alachlor is applied by the farmers as pre emergence herbicides. Field experiment in sunflower (variety CO 1) was conducted during 2010-11 to study the persistence and dissipation behavior of pendimethalin and alachlor in sandy clay loam soil. Treatments imposed were the control (no herbicide), recommended dose and double the recommended dose of herbicides. Soil samples were collected at periodical intervals, extracted for herbicides and quantified by Gas Chromatograph (GC-Chemito Model 8610) equipped with ^{63}Ni electron capture detector. Results showed that the application of pendimethalin at 1.0 kg/ha persisted in soil up to 60 days while up to 90 days at 2.0 kg/ha application rate. However 50% of applied herbicide was degraded from the soil before 30 days after application. Within 60 days of application more than 90% of the pendimethalin dissipated from the soil. For complete degradation from the soil, pendimethalin took 60-90 days. The residues of alachlor persisted in soil up to 30 and 45 days after application under 0.5 kg /ha (x) and 1.0 kg/ha (2x) applied plots. Thereafter the residue concentration went down below detectable level. The residue of pendimethalin and alachlor were below detectable limit in sunflower grain and straw when applied at recommended and double the recommended dose. The dissipation of both the pendimethalin and alachlor followed first order kinetics in the field study. The mean half life for the pendimethalin was 14.1 days while it was 9.8 days for alachlor. Significant correlation was observed between the days after herbicide application and herbicide residue level.

P -36 A study on the mode of evolution of cross resistance against fenoxaprop-p-ethyl in some populations of *Phalaris minor*

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The mode of evolution of resistance to isoproturon in *Phalaris minor* from Haryana was found to be due to detoxification of the herbicide by the enzyme cytochrome P450 monoxygenase. A study on the mode of evolution of cross resistance against ACCase inhibiting herbicides was felt important in providing leads for use of alternate herbicides. This is because, if detoxification mechanism was involved as mode of evolution of cross resistance, herbicides, with different mode of action may not prove effective. On the other hand if target site changes were involved, herbicides with alternate mode of action could be used for managing the resistant populations. The objectives of the study conducted during 2009-2011were to differentiate between involvement of detoxification mechanism versus target site alterations as mode of evolution of cross resistance to fenoxaprop-p-ethyl. Four populations *viz.,* Hisar and Tohana as relatively sensitive and Fatehbad and Jind as relatively more resistant to fenoxaprop were selected for study. The study revealed that cytochrome P450 monoxygenase inhibitors used as (i) a combination treatment of aminobenzotriazole with fenoxaprop or as (ii) a spray of malathion prior to spray of fenoxaprop did not cause reversal of cross resistance as tested by mortality index. Pollen bioassay for determination of target site resistance revealed expression of cross resistance in the pollen grains. GR_{50} value of 0.08, and 0.09 µM was observed in two population *viz.,* Hisar and Tohana. The pollen from Jind population showed a higher GR_{50} value of 0.50 µM and that from Fatehbad showed a value of 5.0µM, thus distinguishing the susceptible from the resistant populations. The data indicated involvement of alteration at the target site as a mode of evolution of cross resistance to fenoxaprop in *P. minor* populations.

P -37 Effect of glyphosate K salt applied in preceding transgenic stacked maize hybrids on succeeding green gram

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Transgenic stacked maize hybrid was developed for preventing yield losses of maize crop to improve productivity. The field experiments were conducted to study the carry over effect of glyphosate K salt applied in preceding transgenic stacked maize hybrids (Mon 89034X NK 603) in succeeding green gram in the experimental site of Tamil Nadu Agricultural University, Coimbatore during *kharif*, 2009 and *rabi,* 2009-10. Glyphosate was applied as POE at 900, 1800 and 3600 g/ha in Hishell and 900 M Gold transgenic maize hybrids compared with non-transgenic counterparts with PE application of atrazine at 0.5 kg/ha *fb*. HW on 40 DAS. Succeeding green gram crop was sown immediately after the harvest of herbicide tolerant transgenic stacked maize hybrids. Post emergence application of glyphosate at various rates in preceding transgenic stacked maize hybrids did not affect the germination percentage and vigour of succeeding green gram. The germination percentage of green gram was in the range of 85 to 98% and also there was no crop phytotoxicity in residual crops observed with different doses of glyphosate and other weed control treatments applied in transgenic and conventional maize hybrids during both the seasons. Total weed density in the succeeding crop significantly altered due to the different preceding weed management practices. During both the seasons, lower weed density was recorded with glyphosate at 3600 and 1800 g/ha when compared to other weed control treatments and also higher total weed density was observed under unweeded check. There was no significant influence on plant height, dry matter, yield attributes and grain yield of residual green gram by application of glyphosate at various rates in preceding transgenic maize hybrids.

P -38 Study on carry over effect of glyphosate K salt applied in preceding transgenic stacked maize hybrids on succeeding green gram

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Transgenic stack hybrid corn was developed for preventing yield losses of corn crop to improve productivity. A field experiment was conducted to study the carry over effect of glyphosate K salt applied in preceding transgenic stacked maize hybrids (TC 1507 x NK 603) in succeeding green gram at the experimental site of Tamil Nadu Agricultural University, Coimbatore during *kharif*, 2010. Succeeding green gram crop was sown immediately after the harvest of herbicide tolerant transgenic maize. The treatments consisted of two transgenic hybrids (30V92 and 30B11 HR) resistant to glyphosate with two different doses of POE of glyphosate at 900 and 1800 g/ha and these were compared with pre-emergence application of atrazine at 0.5 kg/ha followed by hand weeding on 40 DAS in non-transgenic maize hybrids like 30V92, 30B11, BIO9681 (national check) and COHM5 (local check). Glyphosate was applied to preceding transgenic maize hybrids as early POE application at 900 and 1800 g/ha. The result shows that germination percentage of residual green gram was not significantly influenced by weed control treatments imposed on the previous maize crop and there was no crop phytotoxicity in residual crops observed with different doses of glyphosate and other weed control treatments applied in transgenic maize hybrids. Total weed density in the succeeding crops significantly altered due to the weed management practices. There was no significant influence on plant height, dry matter and grain yield of residual crops by post emergence application of glyphosate in preceding transgenic maize hybrids.

P -39 Mobility of herbicides in different types of soils under saturated and unsaturated conditions

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Movement studies were carried out using packed soil columns to know the mobility of technical grade oxadiargyl and butachlor in an Alfisol (sandy loam) and Vertisol (clay loam) under saturated and unsaturated conditions. The study was conducted by taking soil columns as described by Harris (1966). Among two soils, herbicide extracted from vertisols was comparatively more than alfisol in both the herbicides might be due to stronger adsorption in clay soils. Depth of movement was more in alfisols than vertisols due to higher leaching of herbicides in loamy soils than clay soils.Herbicide movement was more in saturated conditions than unsaturated conditions. Higher movement of butachlor in soil column as compared to oxadiargyl could be attributed to higher water solubility of butachlor (23 mg/L) than oxadiargyl (0.37 mg/lt) and stronger adsorption of oxadiargyl on to soil colloids as compared to butachlor which restricted the movement of oxadiargyl in soils. The lower solubility of oxadiargyl than butachlor was mainly responsible for lesser leaching of oxadiargyl than butachlor in soils. Absence of herbicide residues in leachates collected beyond 30 cm depth of the soil column in spite of the high dose of application revealed no risk of ground water contamination. To find the association between movement of herbicide with depth of soil and time correlation was employed. Correlation studies revealed that there was stronger inverse relationship between movement of herbicide and depth for both herbicides, where as week positive relationship between movement of butachlor and oxadiargyl with time. Regression coefficients reveals that type of soil has significant effect on movement of butachlor than oxadiargyl. Further, depth of the soil and time had higher effect on the butachlor than the oxadiargyl. In case of butachlor highly significant association was observed and the independent variables contributed 82 % of the variation in the movement of butachlor, "r" value for movement with depth and movement with time was 0.83 and 0.28, respectively. Among two herbicides studied butachlor exhibited highly significant effect on movement than oxadiargyl.

P -40 Evaluation of weed control efficiency and yield of transgenic stacked maize hybrids

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The development of crop cultivars with resistance to selected herbicides has the positive impact on agricultural production systems and food safety. Transgenic stacked maize hybrids evolved by Monsanto India Ltd., NK603 is gyphosate tolerant. While all other weed flora suppressed after application of herbicides. The transgenic maize hybrids were evaluated during *kharif,* 2009 and *rabi,* 2009-10 at experimental site of Tamil Nadu Agricultural University, Coimbatore. Glyphosate was applied as POE at 900, 1800 and 3600 g/ha in Hishell and 900M Gold transgenic maize hybrids compared with non-transgenic counterparts with PE application of atrazine at 0.5 kg/ha followed by HW on 40 DAS. The total weed density was significantly reduced with POE application of glyphosate at 1800 g/ha in transgenic 900 M Gold and at 3600 g/ha in transgenic Hishell during *kharif,* 2009 and *rabi,* 2009-10 seasons, respectively. POE application of glyphosate at 900, 1800 and 3600 g/ha recorded lower weed dry weight due to effective and timely weed control offered by glyphosate. Higher grain and stover yield was recorded with POE application of glyphosate at 1800 g/ha in transgenic 900 M Gold and 3600 g/ha in transgenic Hishell during *kharif* 2009 and *rabi* 2009-10 seasons, respectively. It was comparable with other doses of glyphosate during both the seasons. Average yield obtained in transgenic hybrids were 10 t/ha and conventional hybrids were 8 t/ha.