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ICAR-NBSS & LUP, North East Regional Centre

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Contents:

From the Desk of Head (Acting)

As an attempt to portrait different issues related to agriculture and allied sectors the 2nd quarterly issue on the Soils-NE is being published portraying different issues of soils viz. Shifting cultivation practiced in the hills of NE region and how to make them sustainable, soil conservation from water and wind erosion through adoption of biological measures and benefits of application of drone technology in agriculture.

Besides an improved technology of agronomic importance raised bed and shunken bed (RSB) was portrayed with suitable example which may benefit the farming community of the region, particularly those who have land holdings in low lying/marchy areas.

To enhance the resilience of hill agriculture covering crops, livestock and fisheries to climatic variability and changes through development and application of improved production and risk management technologies the ICAR is playing a vital role. .

One important environmental issue has been addressed in this issue i.e. judicious application of agrochemicals for cleaner environment and biotic health is also a part of this issue.

The Centre is grateful to our Hon'ble Director and other senior Scientific staff members for their cooperation and encouragements along with the contributors to make this issue of the e-News letter a success.

Regards.

Uday Saikia

(U S Saikia)

1. *The Editorial Team, Soils-NE, ICAR-NBSS & LUP, Jorhat*

2. Application of Drone in Agriculture

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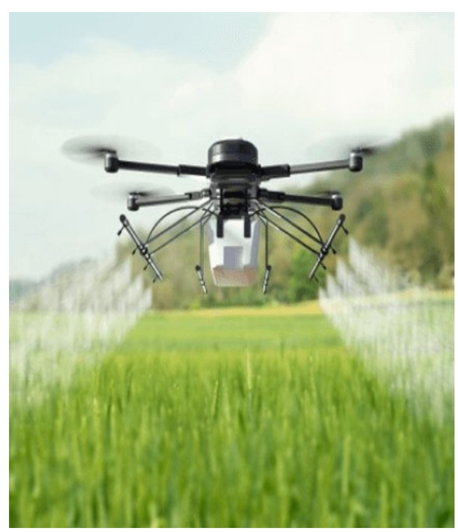
A Drone or Unmanned Aerial Vehicle (UAV) is a device that can fly through air either using GPS coordinates or using radio guidance from a control station. Depending upon the nature of the study there are various techniques that can be utilized in drone operation. Drones are mainly developed to serve as unmanned aerial observer to provide required data in a time and cost effective manner. Drones serving various purposes are equipped with different degrees of autonomy. Some are controlled manually by human operator using some type of communication system and in others autopilot system can control the movement of the vehicle. Drone survey nowadays has become a multidisciplinary practice and presently it is also used as a tool to support overall productivity in agricultural practices.



Agricultural application of drones include crop monitoring, irrigation monitoring, planting, crop spraying, fertilizer and other chemical spraying, health assessment etc. As drone surveys become more common, they also become more cost-effective. In agriculture, they have a plethora of advantages. The farmer can enhance production capabilities through comprehensive irrigation planning, regular monitoring of crop health, improved knowledge about soil health, and adaptation to environmental changes. Drone usage helps getting regular updates about crops and to maintain adequate farming techniques. The farmers can get better prepared for adverse weather conditions and allocate resources without any wastage. It is more secure and convenient for agriculturists to utilize drones to shower pesticides in territories challenging to reach, infected patches, taller crops, and in areas having power lines. Drones can be used on targeted areas specifically which reduce contamination and spread of chemicals in soil. Drone survey helps in gathering accurate information about the crop land and aid decision support system, allowing farmers to be more efficient. Various sensors are available nowadays which can even detect spectral ranges to which human eyes are not sensitive. Infra red rays can carry information about the vegetation cover that can be utilized to measure vegetation indices. With this information one can directly interpret health of the crop, colour, moisture level, density etc. Agri-drones empower ideal utilization of all resources such as fertilizer, water, seeds, and pesticides. The drone survey helps farmers calculate the precise land size, segment the various crops, and indulge in soil study.

It is clear that application of drones in agriculture can positively impact the outcome of such practice. Presently the most important factor in the use of such a tool is spreading awareness of such technology among the farmers. It can transform traditional farming techniques in uncountable approaches. Even though this technology is more complex to be familiar with, it's going to yield its effects very quickly once learned. In India use of drone is allowed under certain conditions. Agricultural growth is the backbone of our country's development. Agriculture constitutes a significant portion of the country's total domestic production. Agricultural production is also critical in maintaining food security goals. Thus, use of agricultural drone technology can play a significant role not only in development of the agrarian community but also in overall growth of the country.

3. Shifting cultivation and its transformation for agriculture development-Part I

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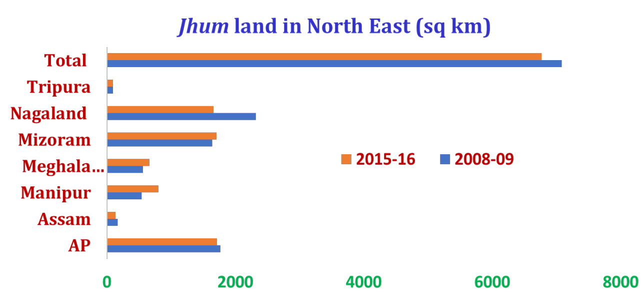
India's North Eastern Region consists of eight states–Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura–occupying 262,179 km^2 and with a population of over 45.58 million (Census 2011) which is 3.77% of India's population. The North Eastern Region is socially, culturally, and politically very complex and contains great environmental and natural resource diversity. More than 200 dominant tribes and many sub-tribes reflect the complex social structure of the region. Agriculture is the mainstay of the economy of northeast India, where more than 80% of the total population is rural. *Jhum* (shifting) cultivation is the predominant land use system in the hilly states of the region.

Shifting cultivation:

Shifting cultivation (*jhum*) is believed to have originated during 7000 BC. A considerable portion of the landmass of the North East is under shifting cultivation. This practice of food production is refined and intensely associated with tradition and socio-cultural values that the people perceive towards livelihood sustenance in the hills. Though, this practice has been projected as harmful, no good alternatives such as agro-forestry or horticultural intervention could infiltrate into the *jhum* areas substantially. The traditional lifestyle, culture and resistance to government policies by the local inhabitants have led to non-adoption of any suggested alternatives to *jhum* cultivation. Since complete eradication of shifting cultivation is practically impossible, research for prescribing resilient shifting cultivation for sustainable development is needed. Effort to develop strategies for resilient shifting cultivation with a goal of sustainable development and livelihood security is the need of the hour.



	AP	Assam	Manipur	Meghalaya	Mizoram	Nagaland	Tripura	Total
2015-16	1713	135	799	661	1703	1661	95	6765
2008-09	1769	165	540	557	1636	2318	95	7081

Viable practices for *jhum* improvement:

Jhum cultivation is a complex issue; it is not possible to replace *jhum* by settled or permanent agriculture. For *jhum* improvement in a holistic manner, alternative technologies need to be explored considering conservation of biodiversity, and other important issues. Involving stake holders; particularly *jhumias,* in deciding the feasible technologies to improve *jhum* be transferred in the *jhum* land. This can be done in a participatory mode with active participation and feedback of *Jhumia's* about their choices regarding the adoption of technology.

Jhum lands are classified into two categories i.e. current *jhum* land and abandoned *jhum* land. Keeping in view of the diversity in bio-physical conditions and resource availability, the approaches for transforming *jhum* lands for agricultural development in two different categories of lands will be different. Some of the approaches for *jhum* improvement are highlighted:

- The *jhum* is a unique agro-ecosystem having distinct agro-biodiversity. Biodiversity in this *jhum* agro-ecosystem comprises of cereals, millets, tuber crops, vegetables, oil seeds, spices, condiments and culinary herbs, floricultural and medicinal plants. Farmers cultivate more than 40 species in the *jhums*. There also exists wide genetic diversity within the species. Besides the agro-biodiversity farmers also use wild plant species as food plants linked with food security. Traditional cultivars of these crops have been conserving from time immemorial through *jhum* practice. These traditional cultivars are either fertilizer non-responsive or very less responsive. There is little scope for replacement of these cultivars with fertilizer responsive HYVs of crops. The farmers are reluctant to apply fertilizers in the *jhum* fields, so HYVs can't give expected yield. Moreover, the fertilizer use efficiency will not be encouraging since most of the applied fertilizers will be lost from the system through surface runoff because of high rainfall in the region. Therefore, effort to develop varieties having good yield potential with low inputs using existing genetic pools of traditional cultivars has some merit. It will also help in conserving diversity of traditional cultivars and protecting soil and water resources from degradation. Tagging of products of *jhum* field as organic will fetch higher prices for which policy intervention is needed for developing market linkages for such products. Expansion of trade to South East Asia under Act East Policy, GOI may provide ample opportunity for marketing of such product.
- Maintenance of high species diversity contributes to the agro-ecosystem stability. With high crop diversity it would be possible to achieve high productivity thorough maintaining high organic biomass content in the system as a whole. Maintenance of higher-level organic matter in soil of *jhum* field (organic by default) helps crops to overcome moisture stress particularly during winter months. High organic matter in soil also prevents soil loss due to erosion. Due to burning, the biomass availability in *jhum* field for soil application is less and therefore, farmers need to be motivated for collection of biomass from adjoining forests. Integrated farming system (IFS) is a production system being followed in the entire north east and livestock/birds component of IFS may serve as an important source of manures for *jhum* fields. Motivation of farmers to dig compost pit adjacent to *jhum* field for utilization of biomass from crop and non-crop areas for production of manures should be given due importance.
- Microbial diversity is an unseen natural resource that deserves greater attention. As the *jhum* is virtually organic production system, bio-fertilizers can play significant role in managing soil nutrients in *jhum* fields. Microbial biodiversity of *jhum* field should be exploited for production of biofertilizers. Biofertilizers produced from native strains of microbes will be far more effective than that of commercial biofertilizers produced elsewhere.
- Replacing slash-and-burn with slash-and-char can improve the quality of *jhum* field soils. Slash-and-char is a carbon and nutrient conserving alternative to existing slash-and-burn technique. Carbon will rather be retained in the system compared to slash-and-burn, since only biomass from the same cropping area will be used for producing the charcoal. A global analysis revealed that up to 12% of the total anthropogenic C missions by land use change (0.21 Pg C) can be off-set annually in soil, if slash and burn is replaced by slash and char. The production of charcoal for soil amelioration purposes could establish a C sink and could be an important step towards sustainability and soil organic matter conservation in *jhum* agriculture. To popularize the slash-and-char practice among the hill farmers of North East, research focus and policy initiatives on popularizing low-cost *biochar* production technologies is urgently needed.

- The shifting cultivation adversely affects soil fertility of *jhum* fields due to soil erosion, loss of organic matter and leaching of plant nutrients.Soil loss can be suitably minimized through adoption of location specific soil conservation measures. Introduction of leguminous cover crops in current *jhum* field will minimize soil loss, improve soil health, suppress weed, provide food to human and feed to animal besides adding cash incomes. Bio-terracing of *jhum* field with fast growing hedgerow species like *Tephrosia candida, Crotalaria tetragona*, *Crotalaria juncea, Indigofera tinctoria, Flemingia macrophylla and Cajanus cajan* has scope for minimizing soil loss and improving the productivity of the soil of current *jhum*fields.
- Crops in *jhum* field suffers from severe moisture stress particularly during winter months that drastically reduce the productivity of the crops. In order to improve the *jhum* productivity, water/moisture conservation options suitable for sloppy land need to be explored. Construction of low-cost micro water harvesting structures with minimum seepage and evaporative losses (*Jalkund* 30,000 l capacity) depending on availability of suitable space in sloppy land will be a viable option for life saving irrigation of crops. Harnessing perennial spring water, if available near *jhum* field, through diversion channels hold promise to overcome the water scarcity problem in *jhum* fields. In-situ conservation of soil moisture through organic mulch may be one of the ideal options. Forest biomass of adjoining *jhum* field may provide source of availability of organic mulch. Vegetative barrier with hedge row species in *jhum* field may provide alternative source of biomass for organic mulch.
- Adoption of Alder based *jhum* system, wherever possible, should be encouraged because it is an outstanding model of sustainable land use system for hilly ecosystem evolved through numerous years of testing. Alder based *jhum* fields are managed typically in four year cycles, with two years of cropping between the alder trees fallowed by two more years while the soil is rested and the coppices allowed to grow.

4. Grass Species for soil conservation

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Soil is a valuable natural resource that nourishes and supports plant growth. When soil is left bare and exposed, it is subjected to erosion by both wind and water. In addition to loss of valuable soil resources, wind erosion can impact air quality and water erosion can result in gullies or “washed out” channels and sedimentation to down slope areas. Soil erosion is a major problem in hilly terrain. The soil can be protected by maintaining a perennial vegetative cover, through mulching, increasing soil organic matter and by adopting suitable engineering techniques. Among the different agronomic practices, covering soil surface with vegetations provides effective erosion control. Maintenance of vegetative cover by growing grasses across the sloppy areas of the hill can overcome the erosion problem to a great extent as grasses posses excellent soil binding properties.

In North-eastern region, soil working for crop cultivation is carried out on hill slopes where erosion losses are very high. Although, bunding is an effective soil and water conservation measure, but it is expensive and requires frequent maintenance. Hence, vegetative barriers comprising of permanent strips of closely-spaced grasses, grown on contours, are effective as an alternative to bunding. Vegetative barrier technology is practiced on gently sloping land ranging from 2–8%. For vegetative barriers, economically important grasses that can provide dense and perennial cover should be selected. Vegetative barriers are beneficial in reducing sheet and rill erosion, ephemeral gully erosion, managing water flow, stabilizing steep slopes and trapping sediment. Furthermore, they provide other products, such as fodder and green manure. Common grass species more particularly the stoloniferous and rhizomatous grasses are more suitable for water erosion control.

1. **Anjan grass or Buffel grass** (*Cenchrus ciliaris)*: It is a good soil binder and hence used as a cover crop on bunds for soil and water conservation. It is mainly used as permanent pasture and can be used as hay and silage. It is propagated by seeds (4 to 5 kg/ ha) and by using rooted slips of maximum six weeks old seedlings.
2. **Bermuda grass** (*Cynodon dactylon*): Popularly known as *Doob ghass* (Assamese: *Dubori bon*) is a perennial grass grown as a turf or as forage for livestock. Bermuda grass establishes quickly in soil through its dense root

system with deep rhizomes. It covers the ground rapidly with its creeping growth habit and protects the soil from erosion. It can be propagated through the rhizomes and stolons.

3. **Broom grass** (*Thysanolaena latifolia*): Broom grass has strong web-like root systems which binds the soil and protect from erosion. It has direct impact in preventing frequent landslides, helping retain ground moisture and fertility, and improving soil quality by reducing soil erosion. Broom grass has the ability to crowd out invasive species when intercropped and is beneficial in retaining soil nutrients to re-grow vegetation. It is propagated through rhizomes.
4. **Citronella grass** (*Cymbopogon nardus)*: Citronella grass can survive in extreme conditions like poor nutrient status, steep slopes and degraded forests. The root system of citronella grass holds the soil firmly and thereby prevents soil erosion. It is mostly propagated through rooted slips.
5. **Guinea grass** *(Panicum maximum)*: Guinea grass is a good soil binder besides being a quality fodder for livestock. It is a fast growing grass having capacity to cover the ground quickly. Hence it can be used for prevention of soil erosion. It is propagated through seeds, rooted slips and stem cuttings.
6. **Lemon grass** *(Cymbopogon flexuosus)*: Lemon grass can be used for soil erosion control purpose as it is a fast growing grass reaching a height of 1 to 1.5 m. It has long roots of up to 2 m due to which it can hold soil firmly and can prevent soil erosion effectively. Lemon grass barriers are very suitable for erosion control in hilly areas. It is mostly propagated through rooted slips.
7. **Napier grass** (*Pennisetum purpureum*) : Napier grass is very tall, fast growing and resistant to drought. It is very effective in reducing erosion losses of sloppy lands. It can be propagated through rooted slips and stem cuttings.
8. **Vetiver grass** (*Vetiveria zizanioides*) : Vetiver, commonly known as Khus khus grass is a perennial grass of Indian origin. It has a massive, fine structured root system. Vetiver grass is used for soil and water conservation, remediation of polluted soils and enhancement of water quality for irrigation purposes. It is propagated through rooted slips.
9. **Congosignal grass** (*Brachiaria ruziziensis*)**:** It is a creeping perennial grass with fast growth habit producing about 30 to 40 tillers per tussock. It protects the soil by rapidly covering the ground areas. It tolerates drought and acidic soil condition. It can be propagated through seeds (2 to 5 kg/ ha) as well as through rooted slips.

5. RSB land configuration in low-lands enhance crop productivity and profitability for farmers of NE India

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Raised and sunken bed (RSB) is a land configuration specially designed by cutting and filling method for low laying areas. Such beds are prepared by removing the surface soil layer from an area and depositing the same on the adjacent area to a height as per requirement.

In Assam, rainfall is very high (average annual rainfall 2,000mm) for which growing crops in lowlands is a major problem during rainy season. Very often crop plants suffer from poor drainage leading to crop failure. Again, it is not possible to grow arable crops (such as vegetables) due to excess moisture after harvest of *kharif* rice in such fields. This is why the land configuration management by converting the land in to RSB system is necessary for the year-round cultivation of diversified crops in a sustainable manner.

Advantages of RSB system

1) Proper utilization of the area throughout the year.
2) Crop diversification and intensification is possible.
3) Increases the productivity per unit area per unit of input use.
4) Enhances income and profitability mainly of marginal farmers.
5) Ensures balanced food supply, conserves natural resources, reduces fertilizer and pesticide loads, and creates employment opportunity.

Preparations of RSB system

1) The field is converted in to Raised and Sunken beds by digging the surface layer of soil and depositing the dugout soil over the adjacent area (Fig.1) to a height as per requirement depending upon that standing water and water table depth.
2) The Raised beds, thus prepared will appear0.3-0.6m higher than that of the adjustment Sunkenbeds. This helps the top soil of the raised beds to be in unsaturated condition which favours the cultivations of arable crops.
3) Width of the beds may be fixed as per convenience; and length of the beds mostly fixed as per the availability of the lands.
4) Removal of the top soils from the Sunkenbeds may reduce the fertility status of the soils. However, application of FYM @10 ton per hectare increases the physico-chemical and biological status of the Sunken beds. Besides, green manuring with Dhancha, Sunnhemp etc. before cultivation of the rice crop is recommended initially for 1-2 years.

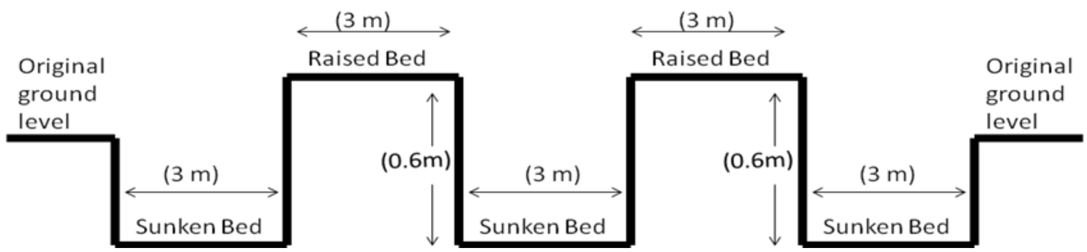


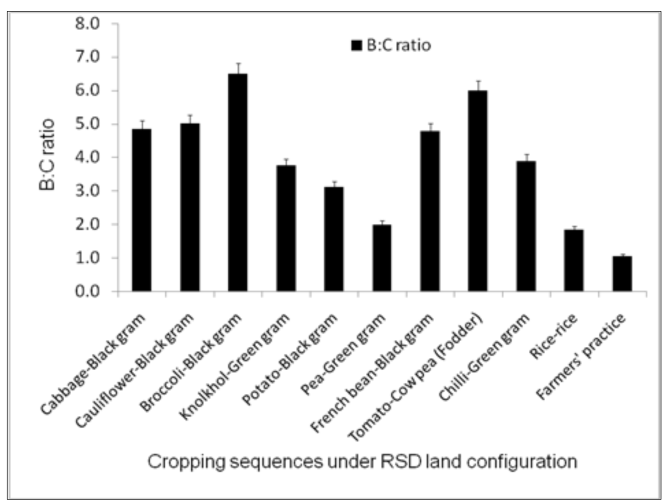
Fig.1 Schematic diagram of alternate Raised and Sunken Beds system

Crops under RSB system

Rice-rice sequence is the suitable system for sunken beds in lowlands. However, rice-colocasia, rice-rice-pea (relay), etc. systems are also suitable for the sunken beds in RSB system. Again, the raised beds could use for cultivation of vegetable and pulse crops or for other remunerative crops. The cropping sequences mostly suitable for raised beds are:cabbage-blackgram sequence, cauliflower-blackgram, broccoli-blackgram, knolkhol-greengram, potato-blackgram, pea-greengram, french bean-blackgram, tomato-cowpea, and chilli-greengram sequence. Besides, 300% cropping intensity is also possible under RSB systems. Vertical cropping with vegetable crops (like pointed gourds, bottle gourds, ridge gourds, squash, etc.) could also be practised successfully using frame made of local material like bamboos above the raised beds for year-round income generation. All the crop management practices should be followed as per the recommended package and practices for the region.

Productivity and profitability under RSB system

The RSB land configuration technique in the low-lying paddy-land of north-east region of India is very promising. The RSB land configuration not only helps in crop diversification and intensification throughout the year but also increase the productivity and profitability over rice monocropping system under long-term. Crop productivity under RSB may increases by over 4 folds as compared to farmer's practice (FP) i.e. the rice monocropping system normally practised by the farmers of NE India. Consequently, enhancement in rice equivalent yields due to RSB could be 230-1511% over the FP.



The net return and benefit: cost ratio (B:C ratio) were also increased significantly due to RSB land configuration. Through RSB land configuration, net income may be raise by 25 to 240 folds over FP. The B:C ratiounder FP may be increased by 75.5-513.2% under RSB land configuration (Fig.2). Studies in AAU (Jorhat) reported about over 2.0 B:C ratio from the cropping sequences (except rice-rice system)under RSB system. Overall, the RSB technique enables the farmers for crop intensification and diversification utilizing lowlands efficiently, increases crop productivity and income throughout the year leading to socio-economic development of the resource-poor farmers.

Various crops grown in RSB system

French bean in Raised bed and *Rice* in Sunken bed

Tomato in Raised bed and *Rice* in Sunken bed

Pea in Raised bed and *Rice* in Sunken bed

Knolkhol in Raised bed and *Rice* in Sunken bed

6. Judicious handling of agrochemicals for cleaner environment and safer biotic health

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Under the present era of challenging weather scenarios and escalating global food demand due to ever increasing human population, agrochemicals are considered to be part and parcel of the farming community, without which it may not be possible to fulfill the required demand in most instances. Right from accomplishing the nutrient requirement up to management of weeds, pests and diseases in crops, farmers are highly dependent on agrochemicals because of its inexpensive, quick and easy nature of application. Agrochemicals released into the air can eventually settle in the ground, be broken down by sun light and water in the atmosphere, or dissipate into the surrounding air which may prove to be a potential pollutant affecting human, animal and plant health. Indiscriminate use of agrochemicals for long run can harm the soil biota, beneficial microorganisms and have residual effects in the environment. It not only leads to the degradation of soil's microbial ecosystem, but, also contaminates the water bodies through surface runoff, the groundwater resources by soil infiltration and also leaves residual traces in rain water. Further, it can also pose risk to the vital organs of marine life, birds and other non target beneficial organisms. Organophosphate pesticide has the potential to interfere with the reproduction process of catfish by altering the vitellogenesis (the process whereby yolky eggs are produced), thereby severely affecting catfish farming. Moreover, agrochemicals can accumulate in bodies of water to levels that kill off insects and zooplanktons which are the main source of food for young fish. Birds which are considered to be an important member of the ecosystem and play a pivotal role in insect pest control and floral pollination are also affected by the exposure to the harmful agrochemicals. Synthetic chemicals including carbamates, organochlorines and organophosphates can cause decline in the population of raptorial birds by altering their feeding behavior and reproduction. Undoubtedly, these chemicals can also cause severe harm to the human health due to long term exposure, mode of application, improper handling, storage and disposing. They can enter the human body by direct contact, respiratory tract, through food or by contaminated water. The symptoms may appear within short time after contact that may include vomiting, nausea, headache, skin rashes, difficulty in breathing, burning of eyes and in severe cases it may lead to coma and finally death. Sometimes indications may not appear immediately but it may show carcinogenic symptoms in later stages. About three million cases are reported worldwide every year that occur due to acute pesticide poisoning, out of which two million are suicidal attempts and rest are due to accidental poisoning.

Considering the above facts and its ill effects, it is high time to disseminate the knowledge on proper and safe handling of agrochemicals so as to minimize the adverse effect on farmers' health and biotic environment caused by its irrational use. The preliminary step towards this noble march is to create awareness among the farming community to use only the permitted chemicals as per recommended doses and standards set by the concerned authority, which will invariably reduce the toxic residual impacts on the health as well as environment. Further, regular inspection of equipments and use of protective clothing including gloves, face masks and safety goggles is a must on the part of the user. Farmers must be trained up on hazards of pesticides as well as on basic precautionary measures that needs to be taken in order to prevent accidental poisoning. They should be taught to read the labels on the agrochemical bottles that provide information on its potential hazards. Proper storage techniques as well as safe disposal of the used bottles should also be taken in to account while dealing with these types of chemicals. In case of poisoning at work place, there must be a minimum first aid available with the users, but, in severe poisoning he must be rushed to the nearest hospital for the right antidote. Considering the safety of the environment use of bio-pesticides should be encouraged in addition to alternative practices like biological control of pests through natural enemies like predators, cultural control like crop rotation that prevents the build- up of specific pest, physical control like use of traps, lures etc., breeding of pest and disease resistant plants and use of genetically modified crops. Thus, in addition to safe handling of agrochemicals, the farmers also need to resort to effective and environmentally sensitive integrated management approaches of pest, disease, weeds etc. which will eventually contribute to a better health and sound environment.

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