Editorial

Weed management in conservation agriculture

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Conservation agriculture (CA) is a system designed to achieve agricultural sustainability by improving the biological functions of the agro-ecosystem with limited mechanical practices and judicious use of chemical inputs. This system comprises three core principles.

i. Direct sowing/planting with minimum soil disturbance using zero, strip or reduced tillage.

ii. Permanent vegetative residue for soil cover, and

iii. Rotation of primary crops in conjunction with other good practices of crop management. Conservation agriculture has been adopted on over 257million hectares (Mha) globally in large farming system and there is an increasing trend of its adoption in small hold farming in Asian countries.

It helps conserve and enhance natural resources, reduces the impact of climate change on crop production and alleviates the factors that cause climate change by reducing emission and contribute in carbon sequestration in soils. This cropping practice increases system diversity by stimulating biological processes in the soil, reduces soil erosion and leaching, reduces production energy inputs by saving time, fuel and cultivation costs as well as reduces labour requirement by about 50%. Soil under conventional tillage is prone to erosion and loss of quality. Soil organic matter depletion has been reported by 16 to 77% due to tillage in conventional agriculture while organic matter build-up in the lands adopting conservation agriculture has been reported. It is because conservation agriculture always maintains permanent soil cover, crop residue retention and mulching that protects soil against deleterious effects of exposure to rain and sun, provides constant supply of food to the micro and macro organisms in the soil and alter the micro-climate in the soil leading shift in microbial population towards more beneficial to crop growth and improves soil aggregates, soil biological activity and biodiversity and carbon sequestration. The crop yields can be similar for conventional and conservation agriculture systems if uniform crop stand can be established and weeds are properly controlled. The crop yield losses in CA due to weeds may vary, depending on weed community and intensity. Weed species shifts and losses in crop yield as a result of increased weed density have been cited as the major hurdles to the widespread adoption of CA. In conventional agriculture maximum operational flexibility and choice of weed control methods are provided while the no-tillage system approaches the lower limit of operational options. The tillage provided by the no-tillage coulter is sufficient to place the seed in the soil, but there is no full width cutting or stirring of the soil. No weed control benefits are derived from this limited amount of tillage. At planting time the soil is covered with residues from the previous season along with weed seeds and any crop seeds missed during harvesting. The soil is firm rather than fluffed, and usually weeds grow profusely. The presence of residues affects the micro environment at the soil surface. The plant residues shade the soil that reduced the evaporative losses of water, leaving the soil cooler and moist. This firm moist soil provides an ideal condition for the germination of small seeded weeds. The plant residue also can interfere with the amount of herbicide applied to reach the soil surface or to germinating weeds. Further, the undisturbed soil surface can have indirect effects on weed control when fertilizers and limes are applied. Nitrogen can lower the pH in the top layer of soil whereas lime can increase it. The efficacy or persistence of herbicides are altered due to the change in soil pH. Weed control in conventional agriculture is achieved generally by turning of the soil through repeated tillage operations prior to planting which disrupts weed seed germination and seedling growth through burial. In cases, where there is probability of emerging difficult to control weed species farmers' use soil applied pre-emergent herbicides having residual efficacy to further reduce the weed germination. The use of selective herbicide application over the top of the crop at a later date sufficiently reduces the weed pressure until the end of the season. However, successful weed control requires producer's attention throughout the season in order to achieve an optimal harvest. It is true that the weed control in conventional system is not a small task while weed control in conservation agriculture poses even a greater challenge to achieve same results as many weed species within agricultural settings are able to flourish when intense tillage operations are minimized. Therefore, conservation agriculture has been characterized by greater weed densities than conventionally tilled crop production practices. In the conservation agriculture system weed control offered from seed burial by tillage operation is lacking and there is no option to incorporate soil applied preemergent herbicides as we do in the conventional system. Moreover, the soil applied preemergence herbicides may have reduced their persistence and efficacy in the presence of plant residues that may intercept and bind the chemical before it reaches the soil surface. This loss of control options forced the farmers to be primarily dependent on post emergence herbicides which often fail to provide adequate weed control. Farmers willing to adopt conservation agriculture initially face shifts in weed population dynamics due to altered distribution of weed seed within the soil, perennial weed species also thrive in the reduced tillage settings and can be difficult to control with the available post-emergent herbicide options. Although several studies report that weed seed bank or viable weed seed within the soil reduces with the use of conservation agriculture and therefore, weed control become easier with chemicals due to increased selection pressures and increased uniform germination, the initial weed control strategies have remained challenging for agricultural lands being switched to conservation system. However, the farmers adopting conservation agricultural practices have increasingly relied on herbicide use.

Herbicides play an important role in controlling weeds during the first years after the adoption of conservation agriculture, at least, in large cropping areas where hand weeding would be inefficient. Three to four years after starting CA, herbicide may still need to be applied in some environments, based on a location-specific knowledge of weeds. Several herbicides are used pre-sowing, pre-emergence or post-emergence and depending on the selectivity of the herbicide to be used. Soil-acting herbicides are mainly used in pre-sowing or pre-emergence treatments while post-emergence ones lack long residual effect in soils. Herbicide-tolerant crops are used in many countries like USA, Canada and Argentina where some broad-spectrum herbicides, such as gluphosinate ammonium and glyphosate, are sprayed over the crops shortly after weed emergence. These herbicides lack soil activity against germinating weeds and may be necessary to be used twice according to weed flushes in the fields.

Early herbicide application to eliminate weed competition in any system is a guarantee for vigorous early crop growth. Rational use of herbicides increases the productivity of the whole cropping process. Herbicides used correctly and at the right rates normally do not pose any problem to the environment. Soil-acting herbicides regularly decompose in soil in a period of 4-6 weeks after their application while most post-emergence ones are quickly dissipated in soil. The major problem with the repeated use of a single herbicide is the possibility of some weed species to evolve resistance. Several herbicide groups, such as sulphonylurea urease, imidazolinones, graminiscides as 'fops' and 'dims', posses a great selection pressure and are able to create problems of resistance in periods of four-six years of their repeated application. The problems of resistance are prevented mainly by crop rotation and avoiding the use of the same herbicide repeatedly. Moreover, application of two or more herbicides in a mixture either formulated or tank mix could increase the spectrum of weed control and helps managing herbicide resistance problems. Various agronomic procedures are included in the conservation agriculture which at the end favors the reduction of weed growth. Crop rotation is useful to break the life cycle of weeds adapted to a particular crop while soil covers create environment congenial to inhibit weed seed germination either by preventing sunlight to the seeds or through the exudation of Allelopathy substances. The use of herbicide is reduced where conservation agriculture is practiced and subsequently herbicide use may be eliminated completely, due to reduction in weed pressure, even the manual weeding is greatly reduced. Some perennial weeds may become problem at early stage of conservation agriculture adoption which will require application of particular systemic herbicides in order to exhaust their underground propagules. Continuous cropping under conservation agriculture will tend to reduce such population as soil is not left bare. In practice, conservation agriculture ultimately offers weed control advantages as weed seeds are no longer spread and incorporated in the soil, or dug up to the soil surface or redistributed through roots parts and it allows the integration of different practices, which makes the system more sustainable. The sustainable weed management can be obtained when control plan takes the following points into consideration.

i. Survey regularly your areas to record major weed species in the field.

ii. Keep in mind that crop rotation is the key for good weed management.

iii. Select cover crops considering the prevailing weed infestation.

iv. Do no leave non-cropped spaces in the field and use correct seed densities as well as row-spacing.

v. Most post-emergence herbicides should be used at early weed emergence, although some systemic compounds as glyphosate are preferred to use a couple of weeks after weed emergence.

vi. Pre-emergence and or pre-sowing soil-acting herbicides are best used with appropriate soil moisture.

vii. To prevent problems of resistance it is important to avoid the use of the same herbicide repeatedly and year after year.

viii. Main objective of weed management should be to sustainable reduction of weed seed bank and not only the control of weeds interfering during the critical periods of competition.

ix. Perennial weed species may require the integration of various control methods to get the required reduction of their stand.

x. Apply herbicide mixtures to increase the spectrum of weed control.

xi. Preventive methods at field level should not either be neglected.

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Conflict of interest

The author declares no conflict of interest.