

WEEDS MANAGEMENT IN ORGANIC FARMING THROUGH CONSERVATION AGRICULTURE PRACTICES

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ABSTRACT

Despite weeds are a serious threat to promotion of organic farming, relatively less attention is given to research on weed management. This article explores a scope of integration of conservation agriculture for weed control and soil protection under organic farming. Limitation in the use of agro-chemicals under OF promotes intensive tillage for weed control. Mostly, tillage leads to depletion of organic matter and proneness to erosion in inclined geography. Adoption of conservation agriculture reduces the intensity of soil manipulation thereby creates an unfavourable condition for weed seed germination, reduces the organic matter depletions and soil erosions. Residues on the surface invite weed and pest predators thereby reduced the weed and pest infestations in organic field. Appropriate crop rotations and cover crops management suppress weeds populations with smothering and allelopathic effects. Thus, CA integration under OF could be an option for weed, pest and soil management which leads to sustainable organic plant production.

Key words: conservation agriculture, erosion, organic matter, tillage, weeds

INTRODUCTION

Weeds are often a major threat in organic farming (OF) and it seems as a key bottleneck for a promotion of sustainable organic plant production (Clark et al., 1998; Bàrberi, 2002). Globally, near about 34% of potential crop yield is reduced by weeds (Oerke, 2006) and yield reduction is more severe under OF systems because of banned in agrochemicals use (Nikolich et al., 2011). In Nepal, herbicide consumption rates are increased by ~400% in 2003 as compared to 1999 under conventional farming for a weed control (Diwakar et al., 2008). Unavailability of appropriate weed control measures rather than the herbicides are the reasons behind it. Despite preventive, physical, biological and cultural measures are available for weed control under OF (Bàrberi, 2002), an intensive ploughing (physical measures) and other intercultural operations being often practicing (Peigné et al., 2007). Mostly, intensive manipulation of soil for weed control increases soil erosions and losses of soil carbon from the soil, especially in the hills and mountains parts of Nepal.

Chemical pesticides (Koirala et al., 2009) and fertilizers (Shrestha, 2010) were introduced in the early fifties in Nepal. Before introduction of agro-chemicals, almost all agricultural areas were organic by default. Interestingly, commercial organic farming was only started since early 1990s after realizing the hazards of agro-chemicals in human and environment (Pokhrel and Pant, 2009). A study conducted by Aryal et al., (2009) shows that demand and willingness to pay for organic product is increasing (13 % of consumers are willing to pay 50% premium and 58% consumers willing to pay up to 20% premium for organic product), whereas the production and productivity of organic products are low in Nepal. The primary reasons could be unavailability of organic inputs, lower crop yields, higher weed problems (Mader and Berner, 2012), lack of structured markets, improper counseling and lack of training on OF (Pokhrel and Pant, 2009). As a result, only 1000 hectares of total

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cultivable areas of country is occupied by OF which is not significant figure (Pokhrel and Pant, 2009). However, research on weed management and quantification of amount of yield losses by the weeds under organic farming is rarely done in Nepal.

Organic farming and conservation agriculture (CA) have two contradictory philosophies for a weed control. OF focuses in no-use of agro-chemicals and promotes intensive tillage for weed control (Bàrberi, 2002). CA is focused on three principles; i) less disturbance of soil by minimum tillage or zero-tillage and use of herbicides for suppression of weeds, ii) retention of sufficient residues on the soil surface, and iii) cover crops and crop rotations to control the weeds, pests and diseases, and protect the soil from erosions (Govaerts et al., 2009, Mader and Berner, 2012). In Nepal, intensive tillage practices in OF to get rid of weeds may be inappropriate technique to control the weeds because two-third of the country's territory comes under the hills and the mountains (UNDP, 2009). Intensive cultivation on the slopes may increase pace of soil degradation by loosening the soil (Acharya and Kafle, 2009). Similarly, concentration of ~ 80% of total precipitation in the monsoon also triggers the losses of organic matter rich soil through erosion (UNDP, 2009). Soil organic matter depletion could be another hurdle to conversion from conventional farming to OF and sustainable OF promotion (Bond and Grundy, 2001).

In this context, this paper explores the possibility of integration of the principles of CA under OF to minimize the weed problems. Furthermore, it also explores the possibility of soil quality improvement, pest and diseases control through adoption of CA principles on organic farming.

REDUCED TILLAGE AND WEED CONTROL

Adoption of reduced tillage or zero tillage under OF slow-down the mineralization of organic matter, resulting slow release of nutrients from soil (Benech-Arnold et al., 2000). The International Federation of Organic Agriculture Movements standards (IFOAM, 2002) recommend that organic farmers should minimize loss of topsoil through minimal tillage, contour ploughing, crop selection, maintenance of soil plant cover and other management practices that conserve soil and should take measures to prevent erosion, compaction, salinization, and other forms of soil degradation'. Especially it is important for Nepal, where most of the areas are sensitive for erosions. Furthermore, adoption of minimum or zero-tillage decreases energy consumption and carbon oxide emissions (Holland, 2004). Williams et al. (2006) stated that intensive tillage under OF increases the environmental burden like global warming and eutrophication rather than its environmental benefit. Therefore, adoption of CA under OF improves the environmental, societal and economic performance in addition to lower weed population.

Reduced or zero-tillage tillage decreases the weed population through creating unsuitable conditions for weed seed germination (Benech-Arnold et al., 2000). Deep and frequent tillage foster for a higher weed population through exposing old and dormant weed seeds to suitable climate (Finch-Savage and Leubner-Metzger, 2006). Intensive tillage tends to increase the some annual weeds, such as, *Chenopodium* sp. and *Papaver rhoeas* by bringing the persistence seeds to the surface (Locke et al., 2002). Tillage also allows diffusion of oxygen from atmosphere into the soil, removes carbon dioxide from the soil, increases the amplitude of temperature and increase the nitrate level (Karssen and Hilhorst, 1992). All those factors help to break the dormancy of weed seed. Although, tillage helps to prepare good seedbed both for crop seeds and weed seeds, the germination rate and nutrient use efficiency of weeds seeds and seedlings would be higher in early stages and thus support for a higher weed population (Mohler, 1993). In addition, tillage also exposes the weed seeds to light and darkness whereby support to break the dormancy of majority of weed seeds (Wesson and Wareing, 1969). A brief sunlight exposure (<10 seconds) is sufficient for weed seed germination (Sauer and Struik, 1964). Thus, by reducing the intensity of tillage to minimum, weed populations can be suppressed under OF.

RESIDUES RETENTION AND WEED CONTROL

As a principle of CA, at least 30% of the soil surface should retain with a residue (Peigné et al., 2007). However, burning of crop residues during land preparation is common in South Asia including Terai region of Nepal to prepare a good seed bed, and possible control of soil borne diseases and pests (Aulakh et al., 2001a). However, burning is not recommended in organic agriculture as it loses the soil carbon and increases the environmental pollutions (Woomer and Palm, 1998, Dinesh et al., 2009). By retaining the residues on the surface reduces the soil runoff by 52.5% and erosion by 80.2% compared to intensive tillage (Yan et al., 2000). Similarly, retention of residues help to increase the soil carbon content and suppress the weeds by modifying the microclimatic condition of soil (Robinson, 1998). In addition, presence of crop residues on the soil surface reduces the possibility of weed seed contact with the soil (Peigné et al., 2007), thus hinders the weed seeds germination rate (Bond and Grundy, 2001). Hence, residues retention on the surface could be a good soil management option for Nepal.

Development of predator habitats are important for promoting weed seeds predation and pest control under OF (Gallagher et al., 1999). Crop residues provide habitat and invite the diversity of beneficial insects, birds and a wide range of invertebrates (e.g. earthworms, small rodents, birds, carabid beetles, field crickets etc.) (Andersen, 2003). Availability of suitable habitats nearby the crop fields support for early colonization of natural enemies (Hunter, 2002). The field managed under minimum tillage or zero-tillage holds the weed seeds on the soil surface that increases the predation possibility of weed seed. For instance, Aphid (*Sonchus* spp.) is a good example of weed predator (Gallagher et al., 1999). Furthermore, closer habitats also support various beneficial insects such as parasitic wasps, lady beetles and syrphid flies, and those predators maintain the crop pest populations below the economic threshold (Norris and Kogan, 2000).

Use of farm yard manure and other crop residues in organic farming systems add organic matter into the soil, whereas improperly decomposed organic matter may become source of weeds (Pleasant and Schlather, 1994). For instance, one kilogram of cow manure contain 42 viable seeds of *Chenopodium album* (Pleasant and Schlather, 1994) and 20 % of seeds can survive after passing from rumen of the animals and after storage (Barberi, 2002). An addition of organic matter increases the microbial activity in soil that potentially increases the weed seed decay (Gallagher et al., 1999). According to Lonsdale et al. (1988), an average 10-16% of seed of *Mimosa pigra* is lost with microbes and the rate of weed seeds decay speeds up in relatively warmer climate and a higher temperature. Similarly, McCloskey et al. (1996) observed a decline in a *Stellaria media* population over 3 years of poultry manure application. The residues on soil surface also help to maintain a higher soil moisture by lower evaporations and maintain favourable condition for microbial populations and accelerate the microbial decay of weed seeds through protecting them from excessive cold and hot temperature (Crist and Friese, 1993).

COVER CROPS, CROP ROTATIONS AND WEED CONTROL

Appropriate crop rotations and growing of cover crops during fallow period helps to suppress the weed population by smothering and allelopathic effect (Peigné et al., 2007). Physical effects of cover crops are the most important to reduce weed population (Barberi, 2002). According to Teasdale et al. (2004), growing of wheat, maize and soybeans in rotation tends to decrease the weed seed bank and abundance of the broadleaf weed. A permanent residue covers or cover crops reduces the sunlight exposure of weed seeds and compete with the weeds for space and nutrient (Rajcan and Swanton, 2001). Use of the cover crops and organic amendments promotes the fungal, bacterial and mycorrhizal communities that may be detrimental to weeds and beneficial for the crops (Norris and Kogan, 2000). Similarly, IFOAM (2002) recommends intercropping to avoid the bare soils, reduce weed population and the erosion.

The rotation of different crops with different rooting patterns promotes a more extensive network of root channels and macro-pores in the zero tilled soil (Hobbs, 2006). This helps in water infiltration to deeper depth and also increases microbial diversity, reduce the risk of pests and disease outbreaks from pathogenic organisms (Hobbs, 2006). Use of legumes as cover crops in rotation helps to fix the atmospheric nitrogen and add the soil carbon which may be utilized by the subsequent crop and improve the soil quality by making phosphorus and nitrogen available to plants (Lu et al., 2000). Leaving the field barren after harvesting of crop, substantial amounts of nitrate is leached out or flushed away from the field as an effect of higher nitrate-nitrogen available after harvest (Dinesh et al., 2009). Growing of non-legume crops in the rotation as a cover crop utilize the surplus nitrogen from the soil that prevent nitrate-nitrogen removal and also reduce the available nutrients for weed germination and its growth (Dinesh et al., 2009; Kuo et al., 1997; Sainju et al., 2007).

OTHER BENEFITS OF CONSERVATION AGRICULTURE

Continuous cultivation in hilly terraces without addition of substantial amount of soil organic matter causes the sharp decrease in soil organic carbon and nitrogen (Shrestha et al., 2006). Depletion of soil organic matter ultimately decreases soil fertility and productivity (Mathema et al., 1999). Increase in tillage rates change the soil structures and break the soil aggregates which trap the stable organic matter for a long period (Six et al., 2004). This accelerates the mineralization of the stable organic matter and emits CO₂ as a product of organic matter decomposition (Six et al., 2004). Conservation tillage in organic farming systems improves the soil fertility by sequestering the soil organic carbon (Al-Kaisi and Yin, 2005). According to Six et al. (2002) maximum amount of soil organic matter is deposited on the top layer of soil in conservation tillage practices resulting high infiltration rate, reduced run off, increased microbial communities and increased binding capacity of soil particles (Six et al., 2004; Klodivko, 2001).

Conservation agriculture creates a favourable condition for microbial population (Alvear et al., 2005). A study conducted in Brazil shows that conservation tillage increases the soil organic matter by 45% and soil microbial population by 83% in 20 year's period in comparison with conventional tillage (Balota et al., 2004). A higher number of Microbial diversities reduce the population of parasitic nematodes (*Pratylenchus thornei*) (Govaerts et al., 2007). Zero-tillage increases the number and diversity of beneficial soil microbes which can compete with the harmful soil organisms and increase the yield of crops (Ramakrishna and Sharma, 1998). Further, reduced or zero-tillage improve the soil structure, increase the nutrient recycling and decrease the pesticides use, greenhouse gas emissions (e.g. Nitrous oxide), eutrophication and cost of the production (Holland, 2004).

CONCLUSIONS

The review study shows the integration of CA techniques and principles under OF seems reasonable for sustainable organic plant production in Nepal. Organic farms/farmers are mainly facing weed and organic matter depletion problems. Depletion of soil organic matter from the field and increased weed pressure limits to further OF promotion. Although a number of approaches have been used for weed control, adoption of CA principles could be an option for weed management under OF. Adoption of reduced or zero tillage makes an inappropriate environment for weed seed germinations. It also stores a higher amount of organic matter by reducing the mineralization rates and subsequently decreases energy consumption and carbon oxide emissions. Crop residues on the soil surface lower the possibility of weed seed germinations by creating obstruction for proper contact to the soil. Similarly, it invites the diversity of beneficial insects, birds and wide range of invertebrates by providing the habitats for weed seeds and pest predators. Maintaining appropriate crop rotation with legume and non-legume crops, and growing of cover crops during fallow period helps to suppress the weed population by smothering and

allopathic effect. Even though, it is important to understand the dynamics of nature and applicability of available practices in different parts of Nepal by implementing field based practices for better understanding the prospect of integration of CA under OF.

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