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Effect of Tillage on Weed Shift and its Managements: A Review

S. Selvakumar[1], R. Ariraman[2]

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ABSTRACT

Tillage is the most important age old practice, which is usefull to create favourable seed bed for sowing of seeds. It also plays a significant role in weed species persistence and its distribution in agriculture fields. Summer plough kills the weed seeds by exposing it to the sun light. Deep tillage helps for the development of enforced dormancy by burring the newly shredded seeds in the deeper layer of soil. Till now no herbicide is available to kill the weed seeds, tillage improves nitrogen mineralization thus in turn enhance the germination of weed seeds. After weed seed's germination, controlling can be done easily with either spraying of herbicides, mechanical and manual means. Now a day's conservation tillage or zero tillage concept is getting picking up. So it is highly important to study the effect of reduced tillage on weeds. Most of the research evidences found that under reduced tillage condition, weed seed accumulation is higher in upper layer of the soil. Annual weed population is predominant in reduced or no tilled soil. In no tillage system before planting soil was applied with non-persistent non selective herbicides to control weeds effectively.

Key words: Herbicide, Tillage, Weed seed bank, Weed species composition.

Tillage has been practiced from ancient days with stirring of soil. Ancient Egyptians, Incas and others began farming by dropping seeds into holes they had made in the soil with sharp sticks. By the 18th century, U.S. farmers had taken oxen or horse teams that pulled crude wooden plows to prepare the soil. It got famous after 1800's. Iron share was invented by John Deere during 1837. After that intensive tillage was followed not only for seed bed preparation but also for weed management. In Indian condition, weeds alone caused economic loss about 11 billion US dollars in 10 major crops in India *viz*., direct-seeded rice (21.4%), transplanted rice (13.8%), wheat (18.6%), sorghum (25.1%), maize (25.3%), pearlmillet (27.6%), groundnut (35.8%), soybean (31.4%), greengram (30.8%), sesame (23.7%), mustard (21.4%) (Gharde *et al.,* 2018). Later it had been found that intensive tillage reduced soil organic matter, destroys soil structure, creation of hard impervious layer beyond the ploughed zone (Ozpinar and Clay, 2006). To avoid those ill effects, concept of conservation tillage aroused (Anonymous, 2001). It again reoriented with minimum tillage and zero tillage. But in minimum and zero tillage weed management becomes the major menace (Krauss *et al.,* 2010, Gruber and Claupein, 2009), especially controlling of perennial weeds become more difficult (Gruber and Claupein, 2009; Sans *et al.,* 2011). So during adoption of theses conservation tillage practices herbicides were extensively used to control weeds (Peigné *et al.,* 2009).

Effect of tillage on soil weed seed bank

Soil act as a reservoir for weed seeds. It is present not only on the top of the soil surface but also spread over the soil profile (Singh *et al.,* 2012; Begum *et al.,* 2006). Tillage was the most important factor in vertical distribution of weed seeds, in that type and time of tillage influences more on vertical distribution of weed seeds in seed bank (Swanton *et al.,* 2000). It consisted of newly shredded seeds to old seeds. Weeds seed bank also contain tubers, bulbs, rhizomes and other vegetative structures of most serious perennial weeds. Agricultural soils contained thousands of weed seeds and a dozen or more vegetative weed propagules per square foot (Menalled and Schonbeck, 2011). Mostly weed seed load was highest in fallow soil due to lack of tillage and plant competition (Archibold and Hume, 1983). In no-till fields, the majority of weed seeds remained at or near the soil surface. When chisel plough was used, 66% of seeds were distributed in the 5 to 10 cm layer, but, usage of mould board plough brought 71% of the seeds at the depth of 10 to 15 cm (Swanton *et al.,* 2000), because of that light and oxygen become unavailable and caused enforced dormancy (Gulden *et al.,* 2003). Even though non photoblastic seeds get germinated, due to deep placement the plume or radicle will not reach the soil surface. Before reaching soil surface stored reserves in seeds will be exhausted (Gulden and Shirtliffe, 2009). It affected the weeds germination. Mostly weed seed present in the soil will be viable for many years. Seed coating and some of the phenolic substances present in the seed coat protect the seeds from attack of pest and pathogens.

[1]Department of Crop Management, Kumaraguru Institute of Agriculture, Erode-638 315, Tamil Nadu, India.
[2]Department of Agronomy, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai-625 104, Tamil Nadu, India.

Corresponding Author: S. Selvakumar, Department of Crop Management, Kumaraguru Institute of Agriculture, Erode-638 315, Tamil Nadu, India. Email: selva4647@gmail.com

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Till now no herbicide was designed to kill the weed seeds. So to reduce weed seed bank in the soil, germination of weed seeds is essential. It can be aided by tillage operation. During tillage some of the underground weed seeds get exposed to the surface of soil and creates favorable condition for its germination. For example weed seeds of predominant species were more prevalent near the soil surface after chisel plowing (Swanton *et al.,* 2000). Adequate amount of rainfall and improved nitrogen mineralisation due to tillage operation (Mickelson and Grey, 2006), accelerate the weeds seeds germination. So further weed management can be done easily by applying herbicide or shallow tillage operations. In this way mostly summer tillage is useful in reducing weed seed bank. In other side tillage reduces the problem of herbicide resistant weeds and weed shift than no tillage, because in no tillage system, weeds are controlled mainly by herbicides. Controlling of particular weed species by repeated use of same selective herbicide caused weed shift. It also affected the efficiency of herbicide (Mickelson *et al.,* 2001). Surface accumulation of seeds under reduced tillage would increase predator access to seeds and therefore it could increase their removal rates. Lack of soil disturbance via tillage could also encourage higher predator populations. No till fields increased the number, diversity or activity of seed-consuming fauna as compared to conventionally tilled fields (Blubaugh and Kaplan, 2015) may be due to increased habitat (Baraibar *et al.,* 2009) or decreased mortality rate (Shearin *et al.,* 2008).

Phalaris minor and *Rumex dentatus* were studies to know it distribution efficiency after puddling. In top 2.5 cm soil layer 0.02% of *P. minor* and 1.24% of *R. dentatus* was found on the surface after puddling, 29.3% *P. minor* of and 33.6% of *R. dentatus* of total weed seed present in upper 12.5 cm soil depth. The reason for higher density of *R. dentatus* seeds in the upper soil layer was due to lower seed density of 16.17 kg/hectoliter when compared with 61.31 kg/hectolitre for *P. minor*. It was mainly due to *R. dentatus* seeds had perianth, which helps in floating. In 10.0-12.5 cm soil layer for both weeds recorded lowest weed seed distribution (Chhokar *et al.*, 2007).

Influence of tillage on weed seed distribution in different soil types

Research papers in weed seed bank studies mostly concentrated on fine texture soil. Clay soil recorded slower seed burial than sandy soils. After one year of experimentation, in sandy soil seeds reached greater depth compared to clay soil. Rainfall and seed weight also influenced the burial dynamics of weed seed (Benvenuti, 2003). Loamy sand soil also recorded 90% of weed seed population in top 5 cm under no till condition (Swanton *et al.*, 2000), usage of chisel plough leaves 63% of seeds at 0-5 cm depth but in mould board ploughing most of the weed seeds buried in deeper layer and less uniform of vertical weed seeds distribution was observed (Swanton *et al.*, 2000). In silty loam soil, the weed seed bank was more homogenously distributed over the tillage depth upto 15 cm with mouldboard ploughing. But in a chisel plough or no-till system more than 60% of the weed seed bank was concentrated in the upper 5 cm of soil depth (Clements *et al.,* 1996). This variation in distribution of weed seed in soil may be due to response of different soil types and its physical character for the applied tillage practices (Benvenuti, 2003). Because sandy soil offers lesser resistant for turning of soil during tillage, but clay soil offer more resistant for turning of soil during tillage (Swanton *et al.,* 2000). Viable seeds and dormant seeds generally higher with conservation tillage than no tillage (Gallandt *et al.*, 2004; Peralta *et al.,* 2011), in no tillage system weed seeds are present at surface of soil, due to that dehydration will take place. So it reduces viability of seeds (Clements *et al.,* 1996).

Influence of ploughing on weed population

Some of the research evidences showed that more annual weeds in no tillage system but in contrast to that some of them reported less weed population under no tillage system Several studies have been found that the effects of tillage vary with weed species, timing and depth of tillage (Selvakumar and Sivakumar, 2021). In particular more grass weeds especially *Phalaris minor, Avena ludoviciana* and *Cynodan dactylon* were commonly observed in conventional tillage with or without residue incorporation compared to zero tillage with or without residue incorporation (Singh *et al.,* 2017). When seed material is absent, no tilled soil weed density is higher. But in the subsequent years weed density is higher in the case of tilled soil (Mohler, 1993). *Aelsmaranthus* and *Digitaria* showed larger seed production in no-tilled soil, whereas winter annual herbs produced more seeds in tilled soil with corn crop. Dominant species were *Amaranthus, Portulaca* and *Digitaria* and least dominant was *Chenapodium* (Mohler and Callaway, 1995). Land ploughed with chisel and mouldboard plough had higher above ground part of lambs quarters compare to sowing with seed drill under no tillage system in silty loam soil with wheat corn rotation (Clements *et al.,* 1996). Most of the weeds are season bound, they emerge only at particular season, so whenever tillage operations coincides with optimum season for weed seed germination accelerates germination of weeds (Chauhan and Johnson, 2009). Tillage without residue incorporation into the soil, will reduce the germination percentage of weeds by fluctuating temperature and light but some of the research evidence showed that germination of weed seeds was improved when moisture deficit occurs (Mohler and Teasdale, 1993). Moss (1979) reported that shallow tillage increase seed production rate of *Alopecurus myosuroids* in continuous winter wheat cropping. Tillage with mulching of rye reduced weed density of some weed species due to allelopathy (Shilling *et al.,* 1985). Chisel plough and mouldboard plough operated field recorded higher weed population. Construction of ridge through tillage stimulated weed seed germination and improved seed production capacity of weeds (Forcella, 1988). Conservation tillage

changed the weed composition. Because it reduced the disturbance in agro ecosystem (Swanton *et al.*, 2000), as the result weed seeds may present near or on the soil surface, so it increases weed population. Mostly perennial weed population especially which produced seeds through asexual means get increased with no tillage system (Clements *et al.*, 1996). Annual board leaved weeds were higher with mouldboard ploughing compared to chisel ploughing and disc harrowing (Knežević, 2008). Some of the research evidence showing that zero tillage recorded lower weed density of *Phalris minor* than conservation tillage, due to higher soil strength. So the development of herbicide resistance in *Phalaris minor* may be avoided with zero tillage and herbicide application. But density of *Rumex dentatus*was higher than zero tillage system (Chhokar *et al.,* 2007). This effect may be due to higher moisture content available at surface layer in zero tillage than conservation tillage after first irrigation. Because soil dries up quickly in conventional tillage system after first irrigation (Chhokar *et al.,* 2007). No tillage system increased surface weed seeds mortality by exposing into extreme weather and predation (Anderson, 2005). In contrast, some of the weed seeds having protection mechanism for safeguarding from extreme weather events like prianth in *Rumex dentatus* (Chhokar *et al.,* 2007) and spikelet in *Aegilops cylindrical*, which encloses seed (Mohler, 1993). So these weed seeds get increased in zero tillage.

Some contrast experimental results showed that the seed bank persistence of volunteer canola was similar after three years under conventional and no-tillage system (Gulden *et al.,* 2004). Canola seed could be persist for three years, if it was buried (Liebman *et al.*, 2001).

Blind tillage as a special practice for weed control

In blind tillage, tillage operation is carried out after sowing and before emergence of crop or crop at early growth stages. It is most effective in case of row crops and cereals. Harrows are generally used to control weeds. In general, corn, soybean and the crop seeds shown at a depth of one inch or more and have quick development of large taproots after germination will tolerate blind cultivation. Blind tillage poorly controls the weed seedlings such as common ragweed, velvetleaf, giant ragweed and annual morning glories that develop roots more than an inch depth, because perennial weeds with well-established root system recorded lesser control with blind tillage (Curran *et al.,* 2019). Generally it is done as soon as the weeds appear and it can be extended until the plant reaches advance stage. Now a days hand operated or power operated hoes are also available for easy weeding. Weeding width can be adjusted according to the spacing of the plants. Rotary hoe or spike tooth harrow is used with the success in the controlling of weeds in young corn, cotton and other row crops. Generally this operation is carried out at two weeks after sowing, whether the crop is up or not. In some the cases, it is done across the rows. 8% of grain yield increase was recorded with first harrowing alone (Bates *et al.,* 2012) whereas second harrowing recorded only additional 3% yield increase. Soybean yield increased with rotary hoeing. Stale seed bed prepared with four passes of rotary hoe could reduce the weed density by 57% (Place *et al.,* 2009). It also improved system productivity and resource use efficiency (Sobhana *et al.,* 2021).

Influence of tillage on chemical weed management

No till soil generally have higher weed density, due to that no tillage system requires more quantity of herbicides compared to conventional farming system (Acciaresi *et al.,* 2003). This will lead to environmental pollution. To avoid this integrated weed management practices can be followed. Mostly tillage combined with herbicide application provided better weed control, thereby it improved crop yield also (Knežević *et al.,* 2008). Changes in tillage practices, changes composition of weed flora, so based on that herbicide should be applied (Selvakumar and Sivakumar, 2021). Response of weed dynamics based on species, location and timing. Increased rate of nitrogen application decreased the annual grass weed population in winter wheat (Valenti and Wicks, 1992) but contrastingly *Setaria viridis* (Peterson and Nalewaja, 1992) and *Avena fatua* (Carlson and Hill, 1986) in wheat crop was favoured by application of nitrogen. Generally tillage reduced organic matter by quickening the oxidation process or increased turnover (Balesdent *et al.,* 2000), especially in case of high organic matter content soil. So herbicide adsorption by the soil organic matter will be reduced in tilled soil condition (Hartzler, 2011). This may improve efficiency of herbicide. In conservation and no tillage farming microbial load was 32% higher compared to conventional tillage (Helgason, 2010), which may favour faster herbicide degradation. But it is not in the case with tilled soil. It initially check microorganism growth (Young and Ritz, 2000), so herbicide degradation is reduced. Pre emergence herbicides mostly forms a thin layer on soil surface with available moisture after application. This inturn will be absorbed by the emerging weeds and killed. It is ineffective on established weeds. Tillage practices help to level the field perfectly. This will helps to formation of thin layer of herbicide on the soil. In conventional tillage, already established weeds will be killed and also it stimulates germination of weed seeds. So at this stage application of selective pre emergence gives better weed control. But it is not in the case with no tillage. In no tillage system, before sowing of crop non selective broad spectrum herbicides are used to kill the weeds. Then during sowing maximum weed seeds will not germinate due to lack of stimuli caused by tillage. So weeds germination will not even. This will resulted in ineffective weed control through pre emergence herbicides (Ishaya *et al.,* 2008).

Weed management in reduced tillage

Reduced tillage increased problem of weed (Nyamangara *et al.,* 2014). To manage this problem we are normally fallowing herbicide application (Melander *et al.,* 2013), it increases herbicide load in soil. This causes environmental

pollution and it also affects the cropping sequence due to residue persistent. Repeated use of same herbicides may causes herbicide resistant weed population especially in case of zero tillage (Tranel and Wright, 2002). This make herbicide weed control as a tedious one. So to avoid those problems integrated weed management can be followed (Melander *et al.*, 2013). First and foremost the field should not be kept as fallow, continuous cropping should be there (Hosseini *et al.,* 2014). There by we can reduce the weed seed accumulation in soil.

In general crop affected by initial quick growth of weeds. So crop species or variety should be screened for its early vegetative growth. There by it suppress weed growth at initial stage. Plastic or residue can be used as a mulch to suppress the weed growth. It also reduces evaporation from the soil surface (Hammermeister, 2016). Cover crops like cowpea, calopogonium can be grown in-between wide spaced crops and it can suppress the weed growth (Dogbe, 1998). In some of the cases, increased seed rate with thicker plant population will reduce the incidents of weeds. This cannot be followed for the crops, when its economic product is seed. Because crowded plant population will produce elongated stem with more foliage due to competition for light interception. So this method is highly beneficial when the foliage of the crop is economic produce. Most of the weeds are season specific. They will germinate when the optimum condition prevails for its growth and development. Mild weather favours growth of most of the weeds. So site and season specific weed management can be adopted with available weed species, density, soil type and season (López granados, 2011). Some of the bio herbicides are also available in the market to control weeds. But those are highly host specific, which will not applicable when mixed population of weeds present in the cropped field. In case of mycoherbicides, compatibility between two or more fungus can be studied. If it is positive, broad spectrum of weeds can be controlled. This research area is lacking. Weeds are having enormous seed production capacity. So major aim of the weed management should be the controlling of weeds before seed setting. In organic farming leaf extract of allelopathic plants can be used to control weeds (Jabran *et al.,* 2015). By optimizing integrated weed management strategies to the each and individual crops, the weed problem in reduced tillage can be managed.

CONCLUSION

This review concluded that varies tillage operations showed a considerable influence on weed population, seed bank and its persistence, moreover tillage also has influence on weed management practices. The tillage operation coincides with favourable season for weed seed germination recorded higher seed germination and growth of weed seeds. Chisel and mould board plough operated fields recorded higher weed density because of inversion of viable weed seeds from the deeper layer. Now a days zero tillage or conservation tillage concept is picking up due to disadvantage of conventional intensive tillage. So it is highly essential to study the changes in weed composition and weed seed distribution under both the tillage system. Grassy weeds are higher under no tillage system, whereas under intensive tillage system, density of broad leaved weeds gets increased. Due to lesser disturbance in soil under both conservation and zero tillage system, perennial weed become more stable and its population also considerably increased. So to control weeds in those area requires more quantity of herbicides. Moreover reduced tillage recorded increased organic matter composition compared to conventional tillage, so absorption of herbicide by organic matter get increased, this in turn reduces the efficacy of herbicide. Hence, the weed control operation need to be standardized to get maximum herbicide efficiency under reduced tillage condition.

Conflict of interest: None.

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