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# Reduced-tillage and Crop Productivity in Indian Arid Zone

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**Abstract:** The increasing costs of energy, equipment, labor and the growing concern over soil loss have paved the way to development of reduced-tillage systems in place of conventional tillage. These residue-retaining reduced-tillage systems are especially effective in controlling soil erosion and substantially enhancing soil water storage. This modification of the soil microclimate by reduced-tillage exerts beneficial effects on the soil microbial communities which plays a great role in nutrient transformations. While minimum tillage allows for minimal soil disturbance during field operations, no-tillage refers to the complete absence of tillage. In practice, if one desires to reap equal or higher yields and better environmental performance with minimum tillage than with conventional tillage systems, several components need to be applied to a conservation agriculture system. This can lead to variable yield responses with the minimum-/no-till management system, especially in a rainfed agro-ecology. Here we review the suitability of reduced-tillage in arid regions, especially with reference to India where experiments on minimum tillage started in the early eighties. The results show limited success with this concept in Indian arid region, where climate and residue availability are a matter of concern. So, successful implementation of reduced-tillage systems as a potential solution to sustainable agricultural intensification needs 1) better understanding of crop and environmental variables and 2) appropriate adoption measures with ample institutional and technology support, over a long term.

**Key words:** Aridity, cropping system, no-till, reduced-tillage, residue.

Tillage is an important process in conventional agriculture for seed-bed preparation and weed management. Several tillage systems are in practice depending upon the equipment used, the degree of soil disturbance brought about and the amount of residue remaining after tilling. The widely adopted full tillage largely mixes and inverts the soil with the help of implements like moldboard plough, disk plough or the chisel plough (Ogle *et al.*, 2012). Adequate tillage ensures efficient weed control, mixing of organic matter inputs and higher yields (Angers *et al.*, 1997; Jorgensen, 2018). However, the high energy requirement and soil compaction due to the heavy machinery used, along with the associated soil degradation and water pollution issues form the major bottlenecks of conventional tillage systems (Foley *et al.*, 2011; Pittelkow *et al.*, 2015). This together with growing concerns over agricultural sustainability has promoted the adoption of conservation agriculture (CA) practices to achieve the global motto of "producing more from less". As defined by the FAO (2011), "CA represents a set of three crop management principles including crop rotation and residue retention/permanent soil cover in addition to the core principle of minimum soil disturbance". Presently, CA is practiced on nearly 180 million hectares of land worldwide, which comprise 12.5% of the arable cropland in the world (Kassam *et al.*, 2018).

No-till agriculture (i.e. absence of tillage) represents one of the soil management practices that have received much attention due to its economic and environmental benefits (Derpsch *et al.*, 2010; Hobbs *et al.*, 2008). No-till is reported to conserve soil resources by reducing wind and water erosion (Verhulst *et al.*, 2010) and by contributing to soil carbon sequestration (Follett 2001). Nevertheless, it is noteworthy that the perceived benefits of no-till are a result of its combination with the other CA principles. In other words, the underlying success of no-till in conserving soil resources is the close linkage between minimum soil disturbance and crop residue management (Derpsch *et al.*, 2014). While conventional tillage practices leave less than 15% residue on the surface, conservation tillage practices leave more than 30% of residue as soil cover (Baumhardt and

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*Table 1. Crop yields under different tillage systems*

| Crops/cropping system | Yield (t ha$^{-1}$) under different tillage systems | | | Remarks |
|---|---|---|---|---|
| | Full tillage | Reduced-tillage | No-tillage | |
| Lupin-Winter Wheat-Winter Triticale-Winter Barley rotation (4 years) | | | | Economic analysis indicated that although all tillage systems were profitable, the income losses in reduced- and no-tillage systems exceeded the value of savings from reduced production costs (Panasiewicz *et al.*, 2020) |
| Winter wheat | 6.8 | 6.4 | 5.7 | |
| Winter triticale | 6.4 | 6.0 | 5.9 | |
| Winter barley | 4.1 | 3.7 | 2.2 | |
| Forage Pea Green Manure-Mustard-Lentil-Wheat rotation (5 years) | | | | The low tillage treatment did not appear to be viable for more than a few years (Fernandez *et al.*, 2019) |
| Wheat | 2.0 | 1.5 | - | |
| Lentil | 0.6 | 1.0 | | |
| Mustard | 1.1 | 0.8 | | |
| Maize-Soybean rotation (4 years) | | | | Reduced-tillage increased soil C and N accumulation rates by 59% and 130% and did not reduce crop yield significantly (Yang *et al.*, 2017) |
| Maize | ~9.5 | ~9.3 | - | |
| Soybean | ~2.6 | ~2.6 | - | |
| Finger millet-Pigeon Pea cropping system (10 years) | | | | After 10 years, the soil organic carbon (SOC) in the top 20 cm soil with no-tillage was 11% higher than with conventional tillage (Prasad *et al.*, 2016) |
| Finger millet | 2.6 | 2.2 | 1.8 | |
| Pigeon pea | 0.9 | 0.7 | 0.4 | |
| Intensive irrigated maize-based systems of north-western India (6 years) (Maize-equivalent system grain yield) | | | | Zero tillage reduced the irrigation water requirement by 40-65 ha-mm and enhanced the system water productivity by 19.4% compared to conventional tillage system (Parihar *et al.*, 2016) |
| Maize-Wheat-Mung bean | 11.0 | - | 12.0 | |
| Maize-Chickpea-*Sesbania* | 7.5 | - | 8.9 | |
| Maize-Mustard-Mung bean | 10.2 | - | 11.9 | |
| Maize-Maize-*Sesbania* | 8.7 | - | 10.1 | |
| Wheat-Mung bean-*Aman* Rice cropping system (4 years) | | | | Zero tillage recorded the highest increase of soil porosity, field capacity and total N, P, K and S in their available forms (Alam *et al.*, 2014) |
| Wheat | 4.0 | 3.8 | 3.2 | |
| Mung bean | 0.9 | 0.8 | 0.7 | |
| *Aman* Rice | 4.3 | 4.0 | 3.8 | |
| Pearl millet (9 years) | | | | Reduced tillage with 100% N (inorganic) gave the highest net returns and rain water use efficiency in Vertisols and Aridisols (Sankar *et al.*, 2012) |
| in arid inceptisols | 1.7 | 1.6 | - | |
| in semi-arid Vertisols | 1.7 | 1.5 | - | |
| in arid Aridisols | 1.7 | 1.7 | - | |
| Winter wheat monoculture (15 years) | 3.0 | - | 3.6 | Soil organic matter, total N and P were 27.9%, 25.6% and 4.4% greater in no-tillage as compared to conventional tillage (Li *et al.*, 2007) |

Blanco-Canqui, 2014). However, results from a large number of studies question the efficacy of no-till agriculture in sustaining long-term crop productivity (Table 1).

The no-till technology has been described differently by different researchers and this creates ambiguity with respect to the conduct and analysis of tillage experiments. In simple terms, no-till represents merely the absence of soil disturbance during field operations. The concepts of minimum tillage, mulch tillage etc. which cause some soil disturbance need to be separated from the no-till procedure. With respect to the Indian arid regions, the harsh climatic conditions, coupled with lack of residue availability, are major deterrent to the adoption of no-till systems. Therefore, in order to look upon no-till as a potential solution to sustainable agricultural intensification with optimum yields and better environmental performance, it is imperative to have a better understanding of its impact on soil microclimate and soil quality *vis a vis* the impact of crop and environmental variables on the no-till system.

### *Impact of no-till technology on soil carbon stock and soil quality*

Several researchers have recommended the adoption of no-till as a soil management method to sequester carbon (Follett, 2001; Lal *et al.,* 1998; Spargo *et al.,* 2008). No-till causes favorable changes in soil structure which confers physical protection to soil carbon with reduced decomposition rates (Jastrow *et al.,* 1996). This has been attributed to the formation of soil C micro-aggregates within macro-aggregates which get released with tillage (Six *et al.,* 2000). Moreover, the absence of ploughing causes an increase in the soil C level of the surface layers leading to a stratification of soil C as a result of no-till (Ogle *et al.,* 2012). Haddaway *et al.,* (2017) systematically reviewed 351 studies and found significant soil carbon stock increase under no-till compared to full-till only in the upper soil (0-30 cm) of around 4.6 Mg $ha^{-1}$ (0.78-8.43 Mg $ha^{-1}$) over 10 years. In contrast, tilled soils support a deeper rooting pattern in crops, leading to higher C input in the sub-surface layers, which also gets mixed throughout the soil due to tilling operations (Baker *et al.,* 2007; Yang and Wander 1999).

A recent meta-analysis of 74 published studies conducted to estimate the influence of no-till adoption on soil organic C stocks revealed the lack of soil carbon enhancement in several no-till systems (Ogle *et al.,* 2012). Reduced C input into soils could be a result of changes in crop productivity, which may increase, decrease or even remain same under no-till. An increase in no-till yields under water-limited conditions due to the better water conservation and better water-use efficiency associated with residue retention on soil surface has been reported (Farooq *et al.,* 2011; Pittelkow *et al.,* 2015). At the same time, in moist/humid regions, no-till practices can reduce crop productivity due to the potential for soil water-logging and compaction that can affect root growth and inhibit crop establishment, subsequently limiting the soil C input (Alvarez and Steinbach, 2009; Van den Putte *et al.,* 2010). The reduced soil C in no-till is, but, compensated by decreased decomposition rates compared to tilled soils (Paustian *et al.,* 2000).

Soil management practices also affect soil microbial population and activities by altering the soil microclimate and soil organic matter dynamics. Several studies have reported microbial abundance in no-till systems with favorable microclimate compared to conventional tillage (Balota *et al.,* 2004; Das *et al.,* 2014; Mathew *et al.,* 2012; Wang *et al.,* 2017). Few studies have, however, reported no difference in microbial attributes with respect to the tillage technique used (Babujia *et al.,* 2010; de Gennaro *et al.,* 2014). A clear picture on the effect of no-till on soil quality is obtained from the meta-analysis of 62 studies conducted by Zuber and Villamil (2016) that confirmed the occurrence of greater microbial biomass and soil enzyme activities (fluorescein diacetate, dehydrogenase, β-glucosidase and urease) under no-till compared to full tillage. The lesser degree of soil disturbance in no-till creates a favorable habitat for functionally diverse microorganisms, especially the mycelial fungi which remain intact and take part in nutrient cycling (van Capelle *et al.,* 2012).

Paradoxically, the microbial activity measured in terms of metabolic quotient (microbial respiration/microbial biomass or $qCO_2$) was greater under tillage than under no-till indicating more active microbes in tilled soil, which is, in fact, an offset for their reduced quantity (Gajda, 2008; Zuber and Villamil, 2016). Johnson and Hoyt (1999) have reported greater activity of microorganisms in tilled soils due to improved access to organic matter inputs, especially in a cooler and moist soil microclimate. Similar results have also been obtained by Balota *et al.* (2004) indicating more active microorganisms under conventional tillage.

In fact, as opined by Ogle *et al.* (2012), in order to get a clear picture on the influence of no-till on soil organic C stock, interactions with other factors such as the basal rate of residue C inputs, climate and soil texture are to be viewed at a regional scale.

*Determinants of successful no-till adoption*

Studies on no-till management suggest a high amount of variation in yields of crops cultivated with the no-till practice; yields may be maintained (Kapusta *et al.*, 1996; Toliver *et al.*, 2012) or increased (Rasmussen 1999; Van den Putte *et al.*, 2010) or even decreased (Howeler *et al.*, 1993) with respect to conventional tillage. These findings point to a multitude of factors that may influence crop performance, especially under a no-till system. Pittelkow *et al.* (2015) have listed the main factors affecting the performance of crops under no-till, based on a meta-analysis of 678 studies in 50 crops from 63 countries. These are:-

*Aridity*

The most important factor affecting performance and yields of crops across different crop categories is the extent of aridity. The study by Pittelkow *et al.* (2015) displayed high yields of no-till under rainfed conditions in dry climate, matching conventional tillage yields, however, under irrigated dry climate and humid climate, crop yields decreased consistently. As stated in a previous section, an increase in no-till yields under water-limited conditions is probably due to the better water-use efficiency associated with residue retention on soil surface.

*Crop category*

Another principal factor affecting the performance of crops under no-till is the type of the crop. Yields of crops like oilseeds, cotton and legumes were found to be at par in no-till and conventional tillage, indicating that they were not affected by the tillage type (Ogle *et al.,* 2012; Toliver *et al.,* 2012). Yields of cereals were moderately reduced under no-till, while horticultural crops and root crops showed drastic reduction in yields (Pittelkow *et al.,* 2015). This may be due to the inhibition of root growth and absence of adequate drainage caused by no-till induced surface soil compaction (Howeler *et al.,* 1993). Though within cereals, yield declines in wheat were lesser when compared to maize, these negative impacts could be reduced when no-till is practiced along with crop rotation and residue retention.

*Duration of no-till*

Majority of the no-till systems show yield declines in the initial years because of the time taken for soils to stabilize following the transition from conventional tillage (Kumar *et al.,* 2012). Pittelkow *et al.* (2015) also reported a similar trends wherein crop yields in the first two years following no-till implementation declined for all crops except oilseeds and cotton, but matched conventional tillage yields after 3-10 years. A recent study on long-term environmental sustainability and profitability of continuous no-till agriculture on yield by Cusser *et al.* (2020) reported that crop yield and soil water availability required 15 years or longer in continuous no-till to generate patterns consistent with 29-year trends of conventional tillage agriculture.

*Rate of nitrogen fertilization*

Nitrogen fertilization is an important aspect in no-till farming wherein the retention of crop residues has a large impact on the accessibility of N by plants, particularly in the initial stages of no-till adoption (Rainbow and Slee, 2004). During the first three to five years, no-till may require greater N fertilizer inputs (for instance, 10-30 kg N $ha^{-1}$ greater for cereal crops) than conventional tillage systems (Derpsch *et al.,* 2014). Without appropriate N fertilization, yields under no-till were reduced by 12%, and with inorganic N fertilization (80-120 kg N $ha^{-1}$) the yield decline reduced to 4%, though it did not significantly reduce the negative effects of no-till (Pittelkow *et al.,* 2015). Interestingly under dry climate, the yield decline without N fertilization was much less compared to humid climate. Also, legume yields under no-till were similar to conventional tillage without N addition (Kihara *et al.,* 2012). With respect to organic N fertilizers, there was a large variability in yield response in no-till systems either because they remained unavailable or were more susceptible to losses as compared to incorporation with conventional tillage.

*Reduced-tillage in Indian scenario*

The paradigm shift in agriculture in the last couple of years mainly due to international trade agreements, wherein direct or indirect subsidies to farmers' continue to be a subject of dispute between the developed and developing nations, and a realization that there is a huge population of underfed necessitate us to increase the benefit-cost ratio of our agriculture system. This warrants proper harnessing of the available resources, which incidentally also forms the basic philosophy behind conservation agriculture (Praveen-Kumar, 2007). In the Indian context, conservation agriculture is popular in the rice-wheat cropping system in the Indo-Gangetic Plains with focus on interventions like zero-till seed-cum fertilizer drill for sowing of wheat in rice-wheat system, raised-bed planting systems, laser equipment aided land leveling, residue management practices, and alternatives to the rice-wheat system (Bhan and Behera 2014; Kumar *et al.,* 2011).

The situation is different under rainfed or dryland agriculture, which is prominent in India, accounting for about 56% of the total cropped area (Kumar *et al.,* 2011). Additionally, the rainfed regions, especially arid and semi-arid areas are characterized by light-textured soils with low organic carbon and low moisture, with erratic rainfall and soil erosion. Conservation agriculture practices are likely to address the above constraints, if adopted on a long-term basis (Kumar *et al.,* 2011). The residue-retaining systems of reduced-tillage and no-tillage are especially effective in controlling soil erosion and enhancing soil water storage by reducing runoff, increasing infiltration and reducing evaporation. As water and soil conservation are highly important for favorable and sustained crop production in arid and semi-arid regions, tillage intensity plays an important role.

Reduced-tillage systems presently advocated for semi-arid to arid regions were developed primarily for crop production in North America and Australia (Praveen-Kumar, 2007). However, in developing countries, these systems may not be applicable without modification for crop production conditions, and should be adopted with caution considering the soil, climatic, social, and economic conditions of the region. Although favorable results have been obtained with reduced-tillage/no-tillage systems in many cases, these are not without challenges. One of the major problems in arid and semi-arid regions is limited crop residue production with non-irrigated crops (Praveen-Kumar, 2007). This may be further aggravated by the use of residue for feed and fuel. Therefore, the scope of residue application under no-tillage in arid regions is largely limited. Furthermore, the harshness of the arid and semi-arid climate enhances the risk of soil degradation by depleting soil organic carbon stock and increasing soil erosion and salinization (Srinivasarao *et al.,* 2015). It is noteworthy that the results of tillage experiments from the sub-Saharan African regions do not advocate the use of no-tillage due to the inherent soil properties and the semi-arid climate (Kihara *et al.,* 2012; Laryea *et al.,* 1991).

The research on reduced-tillage in arid zones of India started in early eighties by the ICAR-Central Arid Zone Research Institute, Jodhpur. Studies showed consistent decline in pearl millet productivity under reduced tillage. Addition of mulch was found to increase crop yield under both tillage and reduced-tillage, but the yields with reduced-tillage continued to be lower than with tillage (Aggarwal *et al.,* 1998; Singh *et al.,* 1998). However, this decline in yield could be arrested by including legumes in cropping system while following reduced-tillage (Kathju *et al.,* 2002). Experiments on rotations of pearl millet with legumes have been tried in arid regions under reduced-tillage conditions. The yield of pearl millet in pearl millet-clusterbean and pearl millet-mung bean cropping systems under reduced-tillage were 5% and 12% higher respectively than that under tillage, while the yields were at par in moth bean-based cropping system, under tillage and reduced-tillage (Fig. 1). This increase in yield was further enhanced with the incorporation of compost in the field wherein pearl millet yielded 75-96% higher in legume-based cropping systems under reduced-tillage than under tillage (Fig. 1). It has been assumed that deep penetration of soil by tap roots of legumes and the consequent addition of organic matter at lower depths by roots would aid in water movement and enhance water use efficiency (Praveen-Kumar, 2007). Further, legumes shed leaves at maturity and thus leaf fall on surface would mimic the effect of residue application thus increasing the productivity of no-tillage systems (Praveen-Kumar, 2007).

Also, as stated in the previous sections, higher microbial activity in plots under reduced-tillage also leads to better nutrient transformation that facilitates plant growth. Moreover, applying organic matter amendments to cropland has also been observed to enhance crop yield under minimum tillage (Singer *et al.,* 2004). Thus,

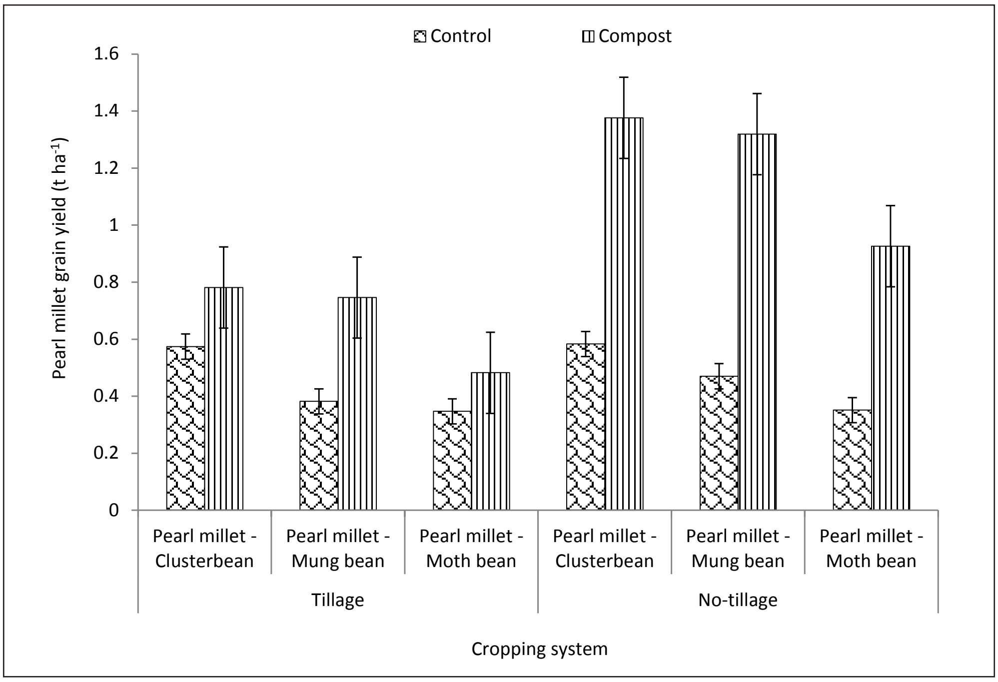


*Fig. 1. Effect of reduced-tillage and residue incorporation on the yield of pearl millet in legume-based cropping systems (Adapted from ICAR-CAZRI Annual Report, 2007).*

choices of crop in a system mode, coupled with soil nutrient status are critical determinants of successful reduced-tillage adoption under Indian arid condition.

Similar studies on the effect of conservation tillage practices on crop yield in semi-arid Alfisols have been conducted at the ICAR-Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad. Tillage methods in combination with residue management were found to significantly influence maize biomass and grain yield, especially after two years of experiment (Reddy *et al.,* 2013). However, reduced tillage, even in combination with *in-situ* crop residue management, gave only small yield benefits in the short run and the treatment combination of disc harrow tillage with residue maize stalk spreading gave the highest average stover and grain yield of 3726 and 2402 kg $ha^{-1}$ respectively (Reddy *et al.,* 2013). Interestingly, no-till recorded slightly more soil moisture than conventional tillage as crop residue mulching helped significantly to conserve soil and water from off-season rainfall events (Reddy *et al.,* 2013). Kumar *et al.* (2011) assessed the techno-economic feasibility of conservation agriculture in rainfed regions of India, based on the results of long-term experiments conducted at the ICAR-CRIDA, Hyderabad, and found that the net benefits varied from Rs. 325 $ha^{-1}$ in a pearl-millet-based cropping system to Rs. 18,000 $ha^{-1}$ in sorghum-based and soybean-based cropping systems. However, the study also reported that the advantage of such practices can be availed in rainfed agro-ecology, only if they are adopted after taking into consideration the rainfall pattern, soil dynamics and also if practiced appropriately over a long-term (Kumar *et al.,* 2011). Though the efforts to adopt and promote conservation agriculture technologies in India have been underway for nearly a decade, it is only in the last five years that the technology has garnered renewed acceptance (Bhan and Behera, 2014). Furthermore, the soils in arid regions are tilled only once per cropping season and therefore, the problems associated with excessive tillage is not quite conspicuous.

## Issues to be Addressed

Principles of conservation agriculture cannot be separated from reduced-tillage in order to reap the full benefits of the system, especially for crops like maize in dry climates, to obtain yields matching with or greater than the conventional tillage agriculture. Hence, successful reduced-tillage implementation requires standardization of several components in the agricultural system and their functional analysis. The main issues to be addressed include:

### *Need for a system approach*

Adjusting and standardizing crop management practices at a system-level is necessary to improve productivity and environmental outcomes rather than simply switching from conventional tillage to reduced-tillage in isolation. Changing only tillage will result in an artificial system that does not reflect the conditions of practical farming (Derpsch *et al.,* 2014). This suggests the development of management techniques different from that of conventional agriculture for the realization of economic and environmental benefits from an optimized system. For instance, control measures in the system should account for system requirements and avoid routine calendar applications. Weed control in reduced-tillage should be performed with the use of adapted, aggressive species of cover crops or by the application of appropriate herbicides. Moreover, these systems should be adapted to local conditions and needs, for raising productivity.

### *Cropping history and soil conditions*

The cropping pattern that was followed prior to the adoption of reduced-tillage and the tillage type that was in use play a great role in the performance of reduced-tillage system. This provides information regarding the type and amount of biomass produced and returned to the soil per year, thereby, affecting the soil C stock. Information on the crop residue left after harvest and more importantly, its distribution also need to be accounted. Soil physical, chemical and biological characteristics are of utmost importance in determining the success of a reduced-tillage system. Transition to reduced-tillage is often accompanied by initial yield reduction in crops due to the time taken for stabilization of soil and development of beneficial soil properties such as increase in soil C, aggregate stability, and available water capacity (Pittelkow *et al.,* 2015).

### *Crop rotation and cover cropping*

The influence of crop rotation and residue management practices on the yield impacts of reduced-tillage relative to conventional tillage has been described in the previous sections. Reduced-tillage after legumes, and especially perennial legumes, has been suggested by Derpsch *et al.* (2014) as a good way to start without expecting a reduction in yield. Surface crop residues serve as a primary form of organic matter input to stimulate soil biological activity, conserve moisture and moderate soil temperature extremes. However, it is imperative to use crop species that use less moisture, also in reduced-tillage management (Gil *et al.,* 2010). As reported by Derpsch and Benites (2003), development of successful cover cropping in reduced-tillage systems has been a major factor in the widespread adoption of this technology in South America.

### *Seeding method and equipment used*

Information on seed spacing, depth of seeding, and the amount of soil disturbance while seeding, along with fertilization regimes add to the process of standardization of the reduced-tillage technology. Inadequate machinery which can cause faulty seeding leading to poor crop stand can adversely affect the reduced-tillage system. The seeding equipment needs to achieve uniform seed depth for good seed-to-soil contact. The importance of equipment used has been described by Zuber and Villamil (2016) who found similar abundance of microbial biomass under chisel ploughed and no-till plots, indicating the less soil disturbance caused by a chisel plough in comparison to other ploughing implements.

Therefore, the performance of reduced-tillage depends on several factors and the proper conduct of the technology is a must to ensure reasonable benefits of soil carbon sequestration, soil moisture retention, crop establishment, soil fertility and crop yields. The above points strongly warrant the need for a multi-disciplinary team in conducting research on reduced-tillage as mastering the technology is highly needed before its implementation in arid zone.

## Conclusions

No-tillage has been the choice of agriculture in places which do not support conventional agricultural practices like the sloppy areas which are prone to soil erosion. Also the system is widely adopted for its possibility of timely planting due to the small window of time available for land preparations, enabling two crops in a year (Calegari *et al.,* 2014). Several studies have revealed the advantages of no-till, when practiced as part of conservation agriculture systems and at the same time, the perceived yield benefits from no-till management is highly debatable. These findings have important global development implications, as dry climates cover more than 40% of the world's land area and support more than 35% of the global population, primarily in developing countries in Asia and Africa (UN Environment Management Group, 2011). With respect to the Indian arid regions, the harsh climatic condition, coupled with the lack of residue availability, is a major deterrent to the adoption no-till systems. Hence, far greater efforts with reduced-tillage systems are needed to obtain sustainability in the dry and hot climatic regions. All these points need to be addressed for a comprehensive systems based approach, with site- and region-specific targeting, in the implementation of reduced-tillage, with adequate success.

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