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Is There Really Anything Like 'No-Till' Or 'Zero-Tillage' Farming? An Obvious Contradiction

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ABSTRACT Despite the all-important role of no-till (NT) or zero tillage (ZT) system, especially in the current fight against climate change effects, there seems to be no current evidence in literature where the grammatical suitability of the term is challenged. The goal here is not to contest the importance of the term, but to close an obvious gap in literature: a situation where users of the term (NT) mean differently from the actual meaning. Although authors agree (whether explicitly or implicitly) that NT farming is a reduced form of soil disturbance, evidences are that the term, which denotes total absence of tillage (cutting/digging or breakage of the soil before planting: a type of soil disturbance), continues to prevail in various discussions, which is an obvious contradiction. The suggestion therefore is that while all efforts to encourage NT practice adoption must increase, however a most suitable term should be considered.

INTRODUCTION

Practices of agricultural sustainability have never been so relevant as they are nowadays when imprints due to effects of climate change and variability are seen in every facet of human endeavor, with agriculture bearing the brunt. Climate change impacts are far-reaching and daunting (Awazi and Tchamba 2019). Evidences (Yadav and Kumar 2017; Awazi and Tchamba 2019; Huang et al. 2020; Gopalakrishnan et al. 2019) are that climate change effect is one of the current topmost global challenges. Human systems highly vulnerable to climate change are agriculture, energy production, fisheries, forestry, human health, industry, insurance/financial services, as well as water resources; in fact, it is said that due to increasing problem of heat, much of the earth's surface may not be habitable by 2300 AD (Yadav and Kumar 2017). The impact of climate change, expressed as droughts or floods which destroy crops, to rising seas which threaten rural people and their livelihoods, has been widely acknowledged across the globe (Bell et al. 2018; Ashrafuzzaman and Furini 2019; Clay and King 2019). Today, climate change is a major reason for natural events/disasters in the world, and the magnitude and frequency will even be more threatening in future years (Rakib et al. 2019). The fear is that if proper actions are not taken, continued emission of the greenhouse gases (GHG) will cause further warming of the atmosphere and create long-lasting changes in all aspects of the earth system, increasing the probability of severe, inescapable and irreparable impacts for humans, the entire ecosystem (Intergovernmental Panel on Climate Change [IPCC] 2014) and the agricultural system which is the main source of energy for the ever growing world population projected to hit the 9 billion mark by 2050.

As indicated, agriculture occupies a central position for the food security of the world. Due to its relevance, how to maintain food production to feed an ever growing population in a rapidly changing global climate, is a current global challenge. Agriculture relates with climate change in a complex cause-effect relationship (Agovino et al. 2019). While agriculture is said to suffer most from climate change effects, agriculture is on the other hand a major contributor to climate change and global warming. Agriculture is predicted to suffer the most from climate change because of its very high dependence on elements of weather and climate to survive (Rao et al. 2019; Agovino et al. 2019). Similarly, be-

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cause marginalized populations of developing countries lack resources to prepare for and cope with climate-related challenges, they have been predicted to be badly hit by climate change effects (Rao et al. 2019). As such, smallholder farmers in sub-Saharan Africa, due to their relative poverty and very fragile characteristics are regarded as first in the list of worst hit areas (Awazi and Tchamba 2019).

According to literature (Awazi and Tchamba 2019; Nguyen et al. 2019; Sustainability 2019), the daunting reality of climate change effects leaves humanity with only two escape routes to get around the menace: adaptation and/or mitigation. Both strategies are complimentary (Landauer et al. 2019) and both help to reduce climate change impacts on agriculture (Nguyen et al. 2019), as well as other earth systems. In simpler terms, Rao et al. (2019) call these two processes adaptive capacity and building of resilience. Adaptation measures are those actions taken to reduce vulnerability to effects due to climate change, while mitigation measures are those actions taken to reduce and limit greenhouse gas (GHG) emissions (Sustainability 2019). Adaptation, therefore, focuses on addressing climate change impacts, while mitigation on the other hand focuses on addressing the causes of climate change (Sustainability 2019). While mitigation has proven very useful on a global scale, adaptation is more effective at local and regional levels (Nguyen et al. 2019).

The need therefore for adaptation and/or mitigation is an indirect need for sustainability. This is why, Mili and Martinez-Vega (2019) maintain that tackling challenges resulting from climate change and variability requires the pressing need to begin a shift towards more sustainable agricultural means. In Nguyen et al. (2019) submission, though climate change is a major threat to farming, however, agricultural sustainability, mitigation and adaptation can effectively reduce the problems. Using conservation agriculture (CA) as an example of sustainable agriculture and climate-smart agriculture, Findlater et al. (2019) emphasize the role CA plays in increasing farm productivity and reduction in risks associated with climate change, when adopted comprehensively.

Based on the foregoing, several sustainable approaches are progressively and increasingly being recognized and adopted today to curb effects due to climate change (Roos et al. 2019; Buchi et al. 2019; Montgomery 2007). One such practice is no-till (NT) or zero tillage (ZT) farming. NT farming approach is defined as a conservation technology where seeds are planted directly into the soil by drilling, with minimal soil disturbance, associated with crop stubble retention, usually treated with herbicide before planting (Powlson et al. 2014). NT is considered to be environmentally sensitive and economically beneficial in curbing carbon (C) emissions, provide stability of higher crop yields, as well as bringing about a reduction in costs of crop management (Roos et al. 2019).

Due to its relevance, there is currently no discourse on sustainable agriculture and climate change adaptation and mitigation in and outside of literature that most probably do not refer to NT approach. However, despite its importance there seems to be no current evidence in literature where the grammatical suitability of the term is challenged. This is the primary objective of this paper. This is necessary because, there appears to be an obvious contradiction in the use of NT: a situation where what users of the term mean is quite different from the actual meaning of the term itself. The goal therefore in this paper is not to contest the importance of the term, but to show based on literature, that the implementation of NT system is not 100 percent free of tillage or soil disturbance, as current usage seems to suggest.

Specific Objectives of this Paper

In order to achieve its goal, specific objectives of this paper are specified as follows:

1. To define no-till as a term. In this respect, effort is made to define NT, first from a dictionary perspective, and secondly from the literature; and
2. To compare no-till with other synonyms of the term as presented in the literature.

OBSERVATIONS AND DISCUSSION

What is No-Till or Zero Tillage Farming?

Dictionary Definition: Meriam-Webster Advanced Learners' Dictionary (Bicknell and Publicist 2008)

No-till is from two root words: no and till. 'No' is defined as 'not at all', reflecting a total or

absolute absence of whatever it is being talked about. Also, 'zero' as a noun means 'nothing at all', and as an adjective, it means 'not any', indicating a total absence of something. Similarly, 'till' means to prepare the land for crop cultivation usually by plowing (cutting into the soil, breaking it up, inverting soil particles with a plow or other implements). Combining all terms, NT or ZT can be defined literally as a total or absolute (100%) absence of tillage or the land preparation carried out on farmland (usually by plowing) before seeding. According to Luder et al. (2019), tillage is the mechanical manipulation of the soil to make its conditions suitable for crop planting. This mechanical manipulation is usually by plowing. Plowing, according to Bicknell and Publicist (2008), refers to digging/cutting into the soil or breaking it up with a plow. Therefore, literally, whenever the term NT is used, the user is saying, there is absolutely (100%) no form of digging/cutting/breaking up of the ground before seeds are planted. The question is, how true can this really be?

No-Till Farming Definitions According to Literature

In the literature, there seems to be an obvious contradiction in the definition for NT farming. While authors agree explicitly that NT is a sort of reduced soil disturbance, they however, continue to use the term 'NT' or 'ZT', which denotes absolute absence of tillage (land preparation done by digging/cutting/breaking up of the soil before seeds are planted, which itself is soil disturbance). In this section, effort is made to analyze certain definitions in literature, to buttress the aforementioned.

A first definition to consider is that by Soane et al. (2012). According to the definition, NT is a system of agriculture where crops are planted without any prior loosening or breaking of the soil by cultivation other than the very shallow disturbance (<5cm) which may have been due to passage of the drill coulters and after which usually 30-100 percent of the surface soil remains covered with plant residues. Based on this definition, three basic deductions can be drawn. One is that tillage is the prior loosening or breaking of the soil by cultivation. The second also is that tillage action is the bigger type of soil disturbance, while the disturbance resulting from actions of the seed drill is only of very shallow form. The third is that, though the term NT, which denotes total absence of any form of cutting, digging and/or breakage of the soil before seeding, is used by authors, they however allude to the fact that for NT system to happen, there is always a form of disturbance (cutting or digging) made on the soil, due to use of the seed drill, though it is a shallow one, thus agreeing with the main argument of this paper.

Similarly, Powlson et al. (2014) define NT as reduced soil disturbance, a system where conventional cultivation is eliminated, and seeds are sown in a slot cut in the soil, causing minimum soil disturbance. Authors in this definition agree that NT refers to reduced or minimum soil disturbance, implying that, while NT is lesser soil disturbance, tillage is a larger soil disturbance, which is in agreement with Soane et al. (2012) submission. Another implication from this definition is that, tillage action cannot be separated from soil disturbance. The question is, what is soil disturbance? Soil disturbance is any action (deliberate or unintentional) that interrupts the natural equilibrium and functioning of the soil. Another question therefore is, if NT is called a reduced form of soil disturbance by Powlson et al. (2014), why then is the consistent use of the term NT, which denotes total absence of cutting/digging or breaking (soil disturbance) of the soil before seed sowing? A further suggestion of this definition by Powlson et al. (2014) is that though the implementation of NT does not allow conventional tillage (soil disturbance), there is however another type of soil disturbance/cutting in the form of seed slots, to allow for seed planting, again agreeing with the contradiction spoken of in this paper.

Other definitions to consider are by Buchi et al. (2019) and Skaalsveen et al. (2019). According to both authors, NT is an agricultural practice where there is the absence of any tillage (Buchi et al. 2019) or a cultivation method without soil inversion (Skaalsveen et al. 2019), but seeds are drilled directly into the soil. Considering these definitions, authors would have been justified for using the term NT, but they however said, that the process requires the drilling of seeds directly into the ground, invalidating therefore the use of the term. This is because, the

drilling talked about in the definition cuts narrow slots for seeds to be planted; meaning that there is always a cut or breakage of the soil. The only difference is that it is not as large as that created when tillage machines are used, thus supporting Soane et al. (2012) and Powlson et al. (2014), as well as the argument of this study.

A further set of definitions to review are those by Busari et al. (2015), Townsend et al. (2016), Vilcek et al. (2019) and Luder et al. (2019). Busari et al. (2015) say that NT involves the cultivation process with little or no soil surface disturbance, however, the only disturbance is during planting. Based on this definition, can we ever be correct to say there is no soil surface disturbance in the implementation of NT, when there is another machine (seed drill) which also cuts the soil, no matter how small the cut? The authors however answered this question in the following statement, that the only soil surface disturbance associated with NT is during planting, supporting the argument of this study. According to Townsend et al. (2016) and Luder et al. (2019), NT farming is an agricultural practice where seeds are drilled directly into the ground or stubble and residue of previous year's crop, with only very minimal soil disturbance. The major highlight of this definitions is that both authors agree there is a very minimal kind of soil disturbance in the implementation of NT, supposedly because of the use of the seed drill, as against the larger kind of soil disturbance when tillage machines are used.

A last definition to talk about is the definition by Vilcek et al. (2019). According to them, NT farming involves a pre-sowing soil preparation, but unlike the tillage method, it is an extreme method of reduced soil tillage, where no movement of the soil is allowed except where necessary to allow for the planting of seeds. Based on this definition, two critical suggestions are made. Firstly, is the fact that authors suggest that no-till involves a certain amount of tillage, but it is the lowest form you can think of. The second, which is most relevant, is that soil tillage is explicitly equated as soil disturbance. This aspect, which though implicitly expressed, is explicitly absent in many other definitions. This fact helps to shed more light on the argument of this paper, that it is unrealistic to say that the implementation of NT does no disturbance at all to the soil, as current use of the term seems to suggest.

No-Till Farming and Its Synonyms

Derpsch et al. (2011), somewhat alluding to the position of this paper, say that there is a current misunderstanding in the literature regarding how NT is defined, which according to them probably causes limitation in the implementation process. For example, sometimes mulch tillage, reduced tillage, minimum tillage, even other forms of tillage, involving various levels of soil tillage disturbance have all been regarded as NT system (Derpsch et al. 2014). In similar manner, Horowitz et al. (2010), point out that agricultural scientists identify several forms of reduced tillage, such as mulch till, ridge till, strip till, and NT, suggesting that NT is a form of reduced tillage. Derpsch et al. (2010) acknowledge NT as ZT farming or conservation agriculture. Concurring, Islam and Reeder (2014) maintain that NT farming is also known as direct seeding, ZT, and sometimes conservation tillage or conservation agriculture. Having a similar view is Skaalsveen et al. (2019) and Townsend et al. (2016), who both agree that NT farming is also called ZT, direct drilling, and occasionally as conservation tillage. Based on the foregoing, four major synonyms are identified relative to NT in the literature. These are ZT, direct seeding/drilling, conservation tillage, and conservation agriculture. The indication is that all other variables in the literature (for example minimum, mulch, ridge, strip tillage), according to this paper, can be classified as conservation tillage practices. The goal in this section is not to disprove any of the synonyms associated with NT, but to show to what extent each synonym truly fits as a synonym and help in validating the argument of this paper.

Conservation Tillage

Taking literally, conservation tillage could be defined as any kind of tillage that seeks to conserve or protect the soil from undue degradation. This view seems to be the view of many definitions in the literature. For example, Townsend et al. (2016) maintain that conservation tillage is any kind of reduced tillage that is associated with at least 30 percent of residue

cover. Similarly, Skaalsveen et al. (2019) suggest that the definition for conservation tillage varies significantly in the literature, but it is often used as a general term which signifies less intensive tillage practices such as NT, minimum tillage and reduced tillage, usually combined with at least 30 percent of residue cover. Having a similar view is Busari et al. (2015). According to them, conservation tillage approach ranges from ZT, reduced (minimum) tillage, mulch tillage, ridge tillage, to contour tillage practices. Lal et al. (2007) say, that conservation tillage includes practices such as strip tillage, cover cropping, contour farming, ZT or chemical tillage, mulch tillage, reduced tillage, and NT/direct seeding. A further submission by Idowu et al. (2019) suggest that though various regions have different versions of conservation tillage practices, the basic objectives remain the same: minimization of soil disturbance and maintenance of surface residue cover; strip tillage and NT were given as examples. Overall, apart from Islam and Reeder (2014), Townsend et al. (2016), and Skaalsveen et al. (2019), who specifically note that NT is sometimes called conservation tillage, NT can best be regarded as an example of conservation tillage, not a synonym, supporting thus the argument of this paper.

Conservation Agriculture (CA)

Even though some authors say NT is sometimes called CA (Derpsch et al. 2010; Islam and Reeder 2014), it may however be difficult to agree with this view. The main understanding from literature, is that NT is a significant first pillar in the implementation of CA (Marandola et al. 2019). According to McClanahan (2019), CA addresses the need for high production output and decreased environmental impacts through the adoption of sustainable practices such as conservation tillage (by implication NT), cover cropping, crop rotation, and nutrient management. CA is a sustainable practice centered on three key principles: (1) continuous minimal soil disturbance through the use of NT/minimum tillage (MT)/strip tillage (ST) technologies; (2) permanent soil organic cover; and (3) crop rotation/combination/diversification on farm (Marandola et al. 2019). As suggestions indicate, there is no basis to equate NT as CA, but a very crucial principle for a successful implementation of CA technology.

Zero Tillage (ZT)

According to earlier definition in this paper, ZT was defined literally as total or absolute absence of any action that breaks/cuts, inverts or dig into the soil in preparation for seed planting. Based on several literature sources (Kumar et al. 2019; Skaalsveen et al. 2019; Townsend et al. 2016; Islam and Reeder 2014; Derpsch and Friedrich 2009; Derpsch et al. 2010), ZT does not differ from NT, hence, it is the most suitable synonym that can be considered for NT. For example, earlier definition by Philips and Young (1973) indicates that ZT is a system of cropping where seeds are planted into untilled soils by cutting narrow slots, trench or band sufficient enough for proper seed coverage; and no other soil tillage is carried out. Also, Kumar et al. (2019) define ZT as an extreme form of minimum tillage, where primary tillage is completely omitted, and secondary tillage is allowed for seedbed preparation in the row zone only.

Similarly, Galdos et al. (2019) define ZT as a farming practice where seeds are sown directly into the soil by a process which causes minimal soil disturbance and ensures surface crop residues are retained. In Roos et al. (2019) terms, ZT is a farming system where seeds are directly drilled into the soil by a process which causes minimal soil disturbance, coupled with left over crop stubble, which is usually treated with herbicides before seed planting, a system promoted to reduce carbon emissions. According to Mutonga et al. (2019), although ZT is rarely used by Kenya's small-scale farmers, it is however a process where farmers perform no cultivation to the soil; chemicals are used to control weeds; and crop residues from previous harvest are left on the soil surface, while plant roots are left in the soil.

A consideration of Kumar et al. (2019) definition suggest that in ZT operation, there is a form of tillage called secondary tillage, allowed only for seedbed preparation in the row zone. Also, "no other soil tillage is carried out" as indicated by Philips and Young (1973) definition implicitly recognizes a form of tillage in zero tillage operations, which obviously is the slot, trench or band

opening for seed planting. Overall, basic observations are that definitions for NT are the same for ZT in the literature. Also, in ZT operation, there is minimal soil disturbance, which some authors (Kumar et al. 2019; Philips and Young 1973) explicitly call a form of tillage, why others (Galdos et al. 2019; Roos et al. 2019; Mutonga et al. 2019) though agreeing implicitly, only call minimal soil disturbance. Another obvious observation is that seeds are directly drilled into the soil. Based on all these, ZT could be considered as the closest synonym to NT in the literature, apart from the fact that both terms denote the same meaning. As discovered so far, ZT involves a certain level of tillage, as in the case of NT, though it is very less in intensity, thus supporting the argument of this paper, that it is unrealistic to say that the implementation of NT or ZT is 100 percent free of soil disturbance.

Direct Seeding/Direct Drilling

Some literature sources have also regarded NT as direct seeding (Islam and Reeder 2014) or direct drilling (Townsend et al. 2016; Skaalsveen et al. 2019), meaning the same thing. As revealed in the literature, instead of the conventional tillage in preparation for seeding, in NT farming, seeds are directly sown with the aid of the seed drill, which can either be tractor-coupled, animal-coupled, hand-driven or the use of a dibble stick (in smallholder farms) (Lal et al. 2007; Powlson et al. 2014; Anjum et al. 2019). According to Keil et al. (2019), a prevailing ZT system uses a ZT drill attached to a relatively small four-wheeled tractor, to sow (for example wheat) directly into un-ploughed soil with only a single pass; and a typical ZT drill opens 6-13 narrow slits using an inverted-T openers to place both seeds and fertilizers at definite depth of 7.5-10 cm. Discussing also on the issue, Kumar et al. (2019) posit that ZT machine carries out four basic tasks in a single operation: (1) clean a narrow strip over the crop row; (2) open the soil for seed incorporation; (3) put the seed; and (4) cover the slot properly.

The seed drill is a tractor-coupled, animal-coupled instrument, or it can even be a dibble stick for smallholder farms. In any case, whether with seed drill machine or a dibble stick, a section of the soil is cut or opened up for seed planting, which is a type of tillage or soil disturbance. This is why some authors have preferred to call the process extreme reduced tillage/reduced /minimum tillage (Philips and Young 1973; Kumar et al. 2019; Vilcek et al. 2019), because at the end of the day, the process is actually a reduced form of tillage or soil disturbance. This is why using the term NT is unrealistic.

CONCLUSION

The main argument of this paper was to try to close an obvious gap in the literature regarding the use of the term NT or ZT farming: a situation where users of the term NT mean differently from what the term actually denotes. The goal was not to contest the importance of the term, but to show based on literature that it is unrealistic to say that there is no tillage action (soil disturbance) whatsoever in the implementation of NT farming system, as current usage seems to suggest. NT farming denotes a system of farming where there is absolute or total (100%) absence of tillage (the land preparation done by plowing before seeds are planted) or soil disturbance. According to literature definitions, some authors explicitly agree that tillage is a type of soil disturbance, and as such, define NT as a reduced form of tillage (using various terms such as extreme reduced tillage, reduced tillage or minimum tillage). Although others do not agree explicitly that tillage is soil disturbance, they however agree implicitly as revealed in certain aspects of their definitions for NT. For example, though NT have been defined as a system of reducing the level of soil disturbance before seeding, they however end with the use of such statements like ‘no other tillage is done’ or ‘except for the shallow disturbance’ or ‘shallow slots cut due to the seed drill’. In essence, though authors agree that NT farming is a reduced form of tillage or soil disturbance, evidences are that the term, which denotes total absence of tillage (cutting/digging/breakage of the soil) or soil disturbance, continues to prevail in various discussions, which is an obvious contradiction.

RECOMMENDATIONS

It is therefore recommended that all efforts to encourage the adoption of NT practice should

be increased. This is particularly necessary because of the relevance of NT for achieving sustainability ideals, and in our current day fight against effects of climate change. However, a most suitable term should be considered for NT: a term which truly matches its meaning.

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