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Review Article

Effect of Long Term Zero Tillage on Yield and Yield Attributes of Wheat: A Review

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ABSTRACT

It is essential to sustainably increase wheat productivity in order to ensure future food security. To feed the rising population on a sustainable basis without degrading natural resources, there is a need to increase farm productivity and total food production. Although the country's green revolution technologies implemented during 1966-67 led to food protection, intensive agriculture, insufficient and imbalanced use of fertilisers, high yielding crop varieties, the use of heavy machinery, excess tillage, etc., resulted in degradation of soil health and quality for more than five decades and increased pollution of air, soil and water. There is a great lack of a systematic approach to relating tillage practises to chemical soil properties. The most significant pillar of conservation farming is zero tillage. The need for an hour is conservation farming. It is a win-win operation for farmers as well as for the environment. Keeping all of these under consideration, this analysis is compiled to create a perfect tillage scheme, i.e. zero tillage, which eliminates the adverse effects of tillage and retains soil resources and eventually contributes to sustainable agriculture. The goal of Tillage was to establish a soil environment conducive to plant growth, but to have negative effects on soil resources, structure and eventually on the environment in the long run. In the long term, zero tillage has the ability to boost the physical, chemical and biological properties of the soil, effectively increasing the production of wheat on a sustainable basis. Zero tillage, both in terms of substantial yield gains and cost savings, produces significant benefits at the farm level.

Keywords: *Zero tillage, Conventional tillage, Yield and yield attributes, Sustainable agriculture.*

INTRODUCTION

The production of wheat depends on proper inputs, better methods of agronomy and tillage. In order to feed an growing population on a sustainable basis without degrading natural resources (soil and water) and the climate, there is a need to increase farm productivity and total food production. It is estimated that by 2050 the global population will be about 9.8 billion and 37 percent of which will reside in China and India (UN, 2017), requiring an estimated 59-98 percent rise in food demand (Valin et al., 2014), placing more pressure on natural resources.

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Although green revolution technologies implemented in the country during 1966-67 led to food protection, intensive cropping, insufficient and imbalanced use of fertilisers, high yielding crop varieties, the use of heavy machinery, excess lawning, etc., for more than five decades resulted in degradation of soil health, decrease in organic matter in the soil, decrease in chemical and physical soil, etc. Organic soil carbon is regarded as an important soil quality index and is considered a key factor in cycling plant nutrients and improving the physical, chemical and biological properties of the soil (Singh et al., 2008). Furthermore, there is a increasing concern now-a-days about elevated atmospheric concentrations of CO2 due to industrialization and other anthropogenic activities. About three times the carbon contained in vegetation is contained in the upper 30 cm soil layer (Powlson et al., 2012), which is known to be most prone to CO2 loss. However, the estimates of total C sequestration capacity in the world's soils vary widely from 0.4 to 1.2 Gt C year-1. Therefore, there is potential for C stock in soils to increase (FAO, 2011). There is also growing concern about the implementation of technologies and management practises that have the potential to increase the content of organic carbon in the soil. Conservation agriculture (CA) has been found to have ample potential for increasing soil organic carbon and soil productivity. In this era of climate change, the CA is a resource-saving agricultural crop production system that aims to achieve fair benefit along with high and sustained levels of production while simultaneously preserving the environment (FAO, 2010). The three interlinked principles of conservation agriculture are: (i) continuous minimum mechanical soil disturbances, (ii) preservation of permanent organic soil coverage and (iii) diversified crop rotations (FAO 2010). One of the aspects of conservation agriculture, zero tillage, refers to soil management systems that result in crop residues covering at least 30% of the soil surface (Jarecki & Lal, 2003). Tillage activity, on the other hand, is synonymous with soil ploughing with some tools and implements to manage weeds and produce a favourable soil tilth for proper seed germination, emergence of seedling, and plant establishment and development (Ahn & Hintze, 1990). Tillage has been found to compact sub-surface soil in the current mechanised agriculture scenario, limiting root penetration and production, nutrient and water availability, and therefore plant growth and yield. The mechanical inversion of the soil does not take place when the tillage is not used for years, and hence the soil-plant system enters into a physical balance. In addition, as a result of reduced soil organic carbon, intensive tillage operations typically increase soil erosion, environmental contamination and soil degradation (Srinivasan et al., 2012). Different scientists have advocated the adoption of zero tillage with the use of herbicides for weed control to minimise organic matter oxidation, sub-surface compaction and better soil environment for root penetration and proliferation, improved nutrient and water availability resulting in improved pant growth and yield. Conservation tillage is now considered a promising alternative to traditional tillage practise (Teklu, 2011). Conservation tillage Conservation tillage practises are becoming economically and ecologically viable choices, including zero tillage or minimal soil disturbance and residue retention on soil surface, as they save energy and provide favourable soil conditions for sustainable crop production and reduced cultivation costs. Better root growth and efficient use of water and nutrients can be encouraged by improved soil physical quality. Long-term conservation tillage enhances the status of soil organic carbon and modifies soil pore geometry, which ultimately affects basic physical parameters such as bulk density, aggregate stability, water retention capacity, etc. However, the effects of conservation tillage are highly variable across climate, soil type and depth, cropping system, and vary widely with the period of adoption.

Impact of zero tillage on yield and yield attributes of wheat

A high priority and urgent need for the feeding of the ever-increasing global population is food security (Chen & Weil 2011). The global population is estimated to exceed 9.1 billion by 2050, according to FAO projections (FAO, 2009). Food protection is further affected by climate change (Wheeler & von Braun, 2013). The only way to achieve food security is to improve efficiency by implementing better production systems that ensure more effective use of inputs, maintain soil and water supplies and reduce fossil fuel consumption. Conservation agriculture (CA) can be a promising alternative to sustainably increase or preserve the yield of crops (Bhatt et al., 2016). The yield advantage of no-tillage, however, is a widely debated issue. On the relative benefits of zero tillage, several studies have reported conflicting findings. There has been comprehensive reporting of higher crop yield in zero tillage than traditional tillage (Singh et al., 2016a). There have also been records of lower zero tillage yields (Tolon-Becerra et al., 2011). In some studies (Alvarez & Steinbach, 2009), crop yields were close. No major yield advantage of wheat and maize in ZT was found in Alvarez and Steinbach (2009) and Zhang et al. (2018). The success of traditional agriculture was highly affected by weather conditions during the growing season (Wang et al., 2006). Many authors have stated that higher zero tillage productivity can only be achieved in dry areas and this may be due to greater preservation of soil water (Triplett & Dick, 2008), while it has very small or even negative impacts in well-drained conditions (Zentner et al., 2002). The experiment of long-term tillage also showed that crop productivity in zero tillage was higher than wet years only in dry years (Bogunovic et al., 2018). The use of ZT in the rice-wheat method in India increased the yield by 5-7% (Erenstein & Laxmi, 2008). Other environment and management variables, such as cultivated crops (Vetsch et al., 2007), rotation (Ribera et al., 2004), management (Sainju & Singh, 2001), site assets (Popp et al., 2002) and years (Pedersen & Lauer, 2003) can also result in yield differences between CA and traditional agriculture. In regions with greater seasonal rainfall variability, the CA can be adopted as the best choice due to its resilience (Sithole et al., 2016). Pittelkow et al. (2015a) conducted a global meta-analysis and revealed that zero tillage decreased the mean yield regardless of residue management and crop rotation. Nevertheless, crop rotation and residue retention in zero tillage in dry climates caused substantial increases in crop yield. Zero tillage system residues protect the soil and enhance physical heat, SOC content and water holding capacity, all of which collectively increase crop yields (Wang et al., 2015). Busari et al. (2013) recorded higher minimum tillage crop yields than zero tillage and traditional tillage. Compared to only zero tillage or rotation, tillage interaction and crop rotation favoured greater productivity (Hulugalle & Scott, 2008). In comparison to non-leguminous crops (barley, canola, flax, safflower, spring wheat, and sunflower), legume crops (dry bean, dry pea, and soybean) typically had positive effects on the next crop, which usually had negative effects (Krupinsky et al., 2006). Germination and decreased root and shoot growth of maize and wheat is inhibited by water extracts from sorghum residues (Guenzi et al., 1967). Field-grown sorghum water extracts influenced the growth of wheat seedlings. Stems, leaves and roots were most inhibitory relative to water controls, reducing radicle elongation of wheat by up to 75% (Ben-Hammouda et al., 1995). In 2014, according to Singh et al., the practise of ZT was found to significantly increase the grain yield of wheat over CT practise in clay loam soil due to a significant increase in the test weight of grains, although despite a significant increase in test weight, there was no significant increase in yield in the loam soil. It had no effect on yield and yield attributing parameters in the sandy loam soil. In an experiment at Pusa (Bihar), Kumar and Sharma (2000) revealed that taller wheat plants were developed by Dhanichaand black gramme as previous crops along with a higher number of tillers compared to crops such as rice, maize, sesamum, sorghum (food) and groundnut. Similarly, in comparison to wheat preceded by rice and sorghum, the dry matter per plant of wheat preceded by dhaincha and black grammes was greater. In the treatments where legumes were introduced into systems, Balyan (1997) also recorded significantly more dry matter and taller plants than the wheat preceded by pearl millet alone. Singh et al. (2003), however, recorded a non-significant difference in the height of wheat plants when cowpea, clusterbean and pearl millet were planted. Wheat after dhaincha (GM) and black gramme produced significantly higher yield attributing character values, whereas wheat prior to sorghum and rice was the lowest (Kumar & Sharma, 2000). In the order of sorghum (food) > rice > maize > sesame > groundnut > fallow > black gramme > dhaincha, the depressing effect of different crops on the yield characteristics of wheat was. After dhaincha and black grammes, the yield of wheat was substantially higher compared to non-legume crops. On the contrary, when followed by groundnut, sesamum, maize, sorghum (food) and rice, wheat yield decreased by 2.76, 7.61, 12.77, 25.18 and 36.48 per cent, respectively, to that of wheat after fallow (Kumar & Sharma, 2000). Compared to pearl millet, the number of tillers m-2, spike length, grain spike-1 and 1000-grain weight were significantly greater when the wheat crop was elevated after cowpea and cluster bean (Singh et al., 2003). With the introduction of legumes either alone or as an intercrop, Balyan (1997) recorded an increase in wheat yield compared to pearl millet alone as a previous wheat crop. Wheat plants m-2, spikes m-2 and grain yields ha-1 have decreased as previous crop residue volume has increased. Maize residues, however, have caused substantial decreases in grain yields (Barraco et al., 2007). In comparison with traditional tillage, improved physical condition, higher SOC content, and better nutrient availability under the zero tillage method resulted in higher yield and water use efficiency (He et al., 2009).

CONCLUSION

The 1960s Green Revolution improved food production, but due to intensive cultivation, heavy farm machinery, excessive irrigation usage, and indiscriminate use of fertilisers and pesticides, there were strong confrontational impacts on the climate, including depletion of SOC stock, increased risks of soil erosion and salinization degradation, and deterioration of physical properties of the soil. Due to the unparalleled increase in the world population and rapid economic growth, the number of food-insecure individuals may increase. In addition, due to growth in popularity, soil depletion, urbanisation, and other competing uses, the per capita cropland region is also declining. The stratagem is therefore to balance food production demand with the need for soil regeneration and reduction of the environmental footprint of agroeco systems. By following sustainable practises such as zero tillage, this can be done. The strategy is to improve soil quality by restoring SOC stock, improving the productivity of inputs for usage, narrowing the yield gap and implementing sustainable agroeco system intensification systems. The goal is to generate more from less soil, less water usage, less fertiliser and pesticide production, and less energy consumption. In order to translate scientific understanding into effect, the much needed paradigm shift will also require the identification and implementation of effective policies. Zero tillage is one of the best solutions properly implemented, with the ability to enhance all physical, chemical and biological properties of the soil, preserve soil and water, and maintain productivity. By designing site-specific packages and informing the agricultural community and the general public about the merits of zero tillage and stewardship of soil resources, its implementation can be strengthened. Finally, we concluded that long-term zero tillage practises could increase the yield and yield characteristics of wheat in a nut shell and conserve soil resources for sustainable agriculture.

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