Original Research Article

ASSESSMENT THE IMPACT OF PREPARATORY TILLAGE SYSTEMS ON SOIL PHYSICAL PROPERTIES AND SOYBEAN PRODUCTIVITY ON VERTISOL OF CENTRAL INDIA

ABSTRACT

Preparatory tillage systems alter soil physical attributes and also affect crop growth and yield. In this sense, this experiment was designed to evaluate the effect of various preparatory tillage systems on soil physical properties and soybean productivity thereby find out a suitable tillage combination for *vertisol* of Vidarbha region of central India. The experiment was laid out in a randomized block design with eight tillage treatments and three replicates. Experimental results revealed that soil physical properties and productivity of soybean differ significantly under various preparatory tillage system and zero tillage. Further data revealed that conventional tillage treatment PTtB (1ploughing + 2 tyne harrow + blade harrow) and PTR significantly improve the soil physical properties like infiltration rate, bulk density, porosity, soil moisture content and grain yield. Conversely zero tillage (ZT) and shallow tillage treatments (BR & HR) did not show any significant improvement in soil physical properties and grain yield of soybean..

Key Words: *Bulk density, Harrow, Ploughing, Porosity, Soybean, Soil Moisture, Tillage*

1. INTRODUCTION

Soybean (*Glycine max*) is one of the most important crops globally, valued for its high protein content and versatility in various agricultural systems. It is a significant source of edible oil, protein for animal feed, and contributes to soil fertility through nitrogen fixation. In India, the area under soybean cultivation the year 2019-20 was 107.62 lakh ha which produced 93.06 lakh metric ton with productivity of 865 kg ha^{-1}, whereas in Maharashtra, the area under cultivation was 37.36 lakh ha which produced 39.42 lakh metric ton soybean grains with productivity of 1055 kg/ha (SOPA, 2019). Nowadays, there is a great concern for food security and environmental conservation since it is anticipated that agricultural food production should increase by at least 70% before 2050 to sustain food security for the increasing population

(Martins *et al*., 2021 and Dubois, 2011). Limited scope in further expansion of global land area necessitates the adoption of efficient and intensive tillage systems to achieve food safety practices for sustainable food production (Paudel *et al.* 2014; Rockstrom *et al.* 2017; Foley *et al*., 2011; Connor and Mínguez, 2012; Maharjan *et al*., 2018). However, intensive use of resources is often associated with several environmental impacts and also leads to soil erosion (Stoate *et al*., 2009; Maharjan *et al*., 2018; Gholizadeh and Kopackova, 2019). Choice of soil tillage is strategic for sustainable agricultural because of its significant impact on soil properties (Chorey *et al*., 2020). Therefore, it is of prime importance to use such preparatory tillage systems that offer high crop yields and, at the same time, preserve soil, water, and biodiversity (Martins *et al*., 2021 and Franchini *et al*., 2012).

The ability of plants to assess minerals and water from the soil is depends on their capacity to develop profuse root systems (Chen and Weil, 2011; Dias *et al*., 2015 and Martin *et al*., 2021). The success of soybean cultivars relies largely on agronomic practices such as tillage, which profoundly influences soil physical properties and, consequently, crop productivity. Preparatory tillage is a primary field operation (plowing, harrowing, or digging) that has been important part of most agricultural systems throughout the years (Busari *et al*., 2015). Tillage practices can be categorized into conventional tillage, reduced tillage, and no-till, each with its distinct impact on soil physical properties and crop productivity. The black cotton vertisol of Vidarbha region have the tendencies towards swelling and shrinkage so it required a high energy input to disrupt hardpan layer and thus to encourage root development and increased drought tolerance (Chorey *et al*., 2020).

Tillage practices play a crucial role in shaping soil physical properties and influencing soybean productivity. For instance, improved soil structure and moisture retention with appropriate tillage systems create favorable conditions for root growth and nutrient uptake, ultimately enhancing soybean yield and quality. Furthermore, the conservation of soil organic matter in reduced tillage and no-till systems promotes long-term soil fertility and resilience to environmental stresses. In contrast, the detrimental effects of tillage on soil physical properties can hinder soybean growth, leading to reduced yields and increased production costs. Farmers of *Vidarbha* region are most commonly follow deep tillage (deep ploughing) once in three years, followed by the clod crushing operation (Khedkar and Deshmukh, 2018). Most of times, majority of farmers prepare their field just by one tyne cultivator and one blade harrow for soybean cultivation (Khedkar and

Deshmukh, 2018). Therefore, the objective of this study was to assess the impact of various preparatory tillage systems on various soil physical properties of *vertisols*, along with development of an appropriate technology to improve that helps to improve soil properties thereby its productivity, especially with reference to semi-arid climate of *Vidarbha* region.

2. METHODOLOGY

The experiment was conducted during *Kharif* season of 2016-17 at the Agronomy research farm of Dr. Panjabrao Deshmukh Krishi Vidyapeeth Akola, situated at the latitude of 22°42' North and longitude of 77°02' East and 281.12 meter above the mean sea level. The climate of the region is semiarid and the determination of mechanical and chemical composition of the soil revealed that the soil of experimental field was silty clay in texture with low in available nitrogen (191.25 kg ha^{-1}), moderate in phosphorus (16.12 kg ha^{-1}) and high amount of potassium (323.72 kg ha^{-1}), having pH value of 7.3 (about to normal). The rainy days during the crop season were 45 having 832.9 mm rainfall. Though rainfall was adequate but its distribution during the crop growing period was quite uneven. As per the recorded data, there was a rainless period during the 24, 29, and 33rd meteorological weeks (MW). During the crop growing season the minimum and maximum temperature ranged between 28.1^{o}C during 28th MW to 41.4 ^{o}C during 22th MW. The minimum temperature varied from 16.5^{o}C during 42th MW to 29.9 ^{o}C during 22th MW.

In order to investigate the effect of various preparatory tillage systems the experiment was laid out Randomized Block design (RBD) with eight treatments having three replications. The tillage treatments comprising with T_1 - Zero tillage + Pre and Post emergence application of Herbicides (ZT), T_2 - 1 Rotavator + 1 PE Herbicide Application + 1 PoE Herbicide Application (HR), T_3 - 1 Blade Harrow + 1Rotavator (BR), T_4 - 1 Tyne Harrow + 1 Rotavator (TR), T_5 - 1 Tyne Harrow + 1 Blade Harrow + 1 Rotavator (TBR), T_6 - 2 Tyne Harrow + 1 Blade Harrow + 1 Rotavator (TtBR), T_7 - 1 Ploughing + 1 Tyne Harrow + 1 Rotavator (PTR), T_8 - 1 Ploughing + 2 Tyne Harrow + 1 Blade Harrow (PTtB). Soybean variety JS 335 was sown on 30th June 2016 with normal spacing (row to row distance of 45 cm and plant to plant distance of 5 cm) and harvested on 18th October, 2016. Periodically observations were recorded on growth and yield contributing character of soybean to evaluate treatment effect. The plants harvested from each net plot were threshed, cleaned and grain weight plot^{-1} was recorded separately. The grain yield was then converted into yield per hectare (kg ha^{-1}). Observations related to physical properties of soils were recorded as discussed below.

Infilration rate (cm hr^{-1})

Double ring infiltrometer (Michael 1999) was used for measurement of infiltration because of its reliability and accuracy. Outer cylinder with diameter 60 cm and inner cylinder with diameter 30 cm having 25 cm height, point gauge for measurement of water level, and stopwatch to record the time. The cylinders were installed 10 cm deep in the soil. Care was taken to maintain the same installation depth for different tillage treatments under study. Water level in cylinder was recorded with the help of point gauge. The stopwatch and point gauge were used to record the predetermined time interval and water level respectively. Observations were continued till the infiltration rate approached a constant rate.

Moisture content (%)

Moisture was estimated by 'GIRL soil profile moisture meter' made by Data flow System Pty Ltd, New Zealand from the depth of 0-10,10-20 and 20-30 cm. Moisture meter was consisting of a sensor, central probe (1 m length) and a data saver. For measuring the moisture in the field, soil access tubes were inserted in the ground up to 50 cm depth. The moisture was measured directly by inserting the sensor into the access tube. It takes reading automatically after every 30 second. The readings were recorded in data logger. The recordings were converted to 0-10 cm, 10-20 cm and 20-30 cm depth in graphical format and in numerical values. Finally, the values were averaged from each spot to get the representative reading for the depth of 0-30 cm.

Bulk density of soil (Mg m^{-3})

For determination of bulk density, the core sampler method (Blake and Hartge, 1986) was used to collect the undisturbed soil samples. The standard core sampler with height and diameter of 200 mm and 80 mm respectively, was used. Three numbers of samples were drawn from each experimental plot at the interval of 20 days. The undisturbed core samples were then oven dried at 105^0C for about 24-48 hours, till the constant weight was obtained. The bulk density was calculated by using the following formula.

$$\text{Bulk density (g cm}^{-3}) = \frac{Weight\ of\ oven\ dry\ soil}{Volume\ of\ soil}$$

Volume of the soil is the inner volume of the core sampler, which was calculated by $\pi r^2 h$, where, r is the radius and h is the height of the core.

Porosity of soil (%)

The porosity of soil mass is the ratio of volume of the voids to the total volume of given soil mass (Singh 1980). The porosity of soil was determined from the relation of dry bulk density and particle density. The relation between the dry bulk density and porosity is.

$$\text{Porosity (\%)} = [1 - \frac{Bulk\ density}{Particle\ density}\ X\ 100]$$

Where, particle density of soil = 2.65 g cm^{-3}

3. RESULTS AND DISCUSSION

3.1 Infiltration rate (cm hr^{-1})

The rate of infiltration is determined by soil-water characteristics including ease of entry of water in soil, storage capacity and transmission rate through the soil. The data obtained from study are presented in Table 1 revealed that the rate of infiltration increased, as magnitude of tillage increased and mean values decreased to a higher extent at harvest (6.43 cm hr^{-1}) when compared to its initial status (7.93 cm hr^{-1}). The data further reveals momentous effect of various tillage practices over IR. At the time of sowing; lowest IR was recorded with the zero tillage treatment ZT (7.21 cm hr^{-1}) followed by shallow tillage treatments of HR (7.64 cm hr^{-1}) and BR (7.58 cm hr^{-1}), while it remains statically similar with each other. However, maximum improvement in IR at sowing was observed with tillage treatment of PTtB (8.60 cm hr^{-1}). It was closely followed by treatments PTR and TtBR with respective IR values of 8.52 and 8.03 cm hr^{-1}, all being statistically similar with each other. There was moderate increase in IR values in medium tillage treatments of TR (7.94 cm hr^{-1}) and TBR (7.89 cm hr^{-1}). As far as IR at the time of harvest is concerned, though the IR values were lower than that of sowing; at all the treatments. At this stage; maximum improvement in IR was noted with deep tillage treatment of PTtB by registering the value of 7.20 cm hr^{-1}. However, it was closely followed by treatments PTR (7.09 cm hr^{-1}) and TtBR (6.83 cm hr^{-1}), all being statistically non significant with each other. It was interesting that maximum reduction in IR values at harvest compared to sowing was noted in BR and HR tillage treatments with respective values of 5.42 and 5.74 cm hr^{-1}.

The higher values of rate of infiltration with treatments consisting of deep tillage could be attributed to less compaction, higher mean weight diameter, lower bulk density and higher soil porosity. Ahuchaogu *et al.* (2015) also recorded significantly higher rate of infiltration with plough+ harrow tillage (24 mm/hr) treatment. It also indicates that the probable subsurface compaction through the high speed rotavator cultivation can be minimized by ploughing the soil either through MB plough or tyne harrow, just prior to rotavator operation. The lower rate of infiltration in treatments HR and BR suggests inferior physical properties at the upper soil surface.

3.2 soil moisture content (%) at the depth of 0-30 cm

Depth of 0-30 cm is considered as the most important for root proliferation in soybean. The data in respect of soil moisture content presented in table 2 indicate that there was no significant difference in moisture content at 20 DAS and at harvest because of receiving sufficient effective rainfall during that stage. The difference among various tillage practices in conserving the moisture can clearly be seen at 60 DAS as there was least amount of rains received during this period. Thus, from the data of 40, 60 and 80 DAS, it can be inferred that deep tillage practice consistently improved the status of soil moisture not only under adequate rainfall condition but also under the condition of inadequate receipt of rainfall. This significant improvement in water conservation with PTR and PTtB may be attributed to loosening of soil to a higher depth coupled with increased porosity and higher mean weight diameter. The soil compaction below the operational depth of rotavator and blade harrow in case of treatments BR and HR may have resulted in less percolation of water up to the depth of 30 cm; reflecting in lowest availability of soil moisture for the plant growth. The lowest moisture content was recorded with shallow tillage treatment of BR at 40, 60 and 80 DAS. Treatment of ZT stored more water as compared to shallow tillage treatments of BR and HR at all growth stages of crop. The medium tillage treatments (TR, TBR and TtBR) stored more water than ZT, HR and BR but lesser than PTtB and PTR.

It is well known that the degree of tillage operations highly affects the soil moisture content at various depth, even though the soil is having same physical properties. It might be due to the amount of moisture the soil retains under a given condition is closely related to porosity and size of voids as well as properties of the soil particles. The soil moisture is modified by tillage through particle to particle contact and porosity of the soil. Barua *et al*. (2014) reported significant reduction in soil moisture with the reduction in depth of operation. Similar observations were recorded in their investigation by Karuma *et al*. (2014) and Meidani (2014).

3.3 Bulk density (Mg m^{-3}) of soil at the depth of 0-15 cm

A thoughtful perception of the data presented in Table 3 revealed that bulk density (D_b) consistently increased with subsequent depth; and in general it also increased from sowing to till harvest of the crop, however, during the period of present investigation, it again somewhat decreased after 60 DAS because of presence of more water at 80 DAS and at harvest as compared to 60 DAS. The initial value of D_b was 1.34 Mg m^{-3} and it was significantly changed with different tillage treatments. At 20 DAS, significant improvement in values of D_b was noticed with deep tillage treatments of PTtB and PTR, where its values were 1.11 Mg m^{-3} in both the treatments. As the depth of tillage decreased, as in case of TR, TBR and TtBR, the soil compaction seems to be increased to a tune of 1.13, 1.15 and 1.12 Mg m^{-3}, respectively as compared to deep tillage operation (i.e. PTtB and PTR). Lowest improvement in the values of D_b was noticed with zero and shallow tillage treatments. At 40 DAS, the values of D_b somewhat increased in all treatments except at PTtB, where it recorded same value of D_b as observed at 20 DAS. Significantly highest D_b value was reported in treatment BR (1.24 Mg m^{-3}) that was statistically similar with treatments of ZT and HR. Similar trend was noticed at 60 DAS, 80 DAS and at harvest, where treatments TtBR and PTR reported lowest values of D_b and maximum D_b value reported with treatment of BR. It is noteworthy to mention that, the values of D_b were consistently lower (1.20 and 1.22 Mg m^{-3}) at the time of harvest with treatments PTtB and PTR, respectively, being statistically similar with each other. Thus, the effect of deep ploughing followed by tyne harrow, blade harrow/rotavator seems to be more long lasting for improving the soil bulk density as against the operation of rotavator either sole or with blade harrow and ZT.

It is well known that bulk density affects almost all the physical properties of soil i.e. infiltration, hydraulic conductivity, available water capacity, soil porosity and rooting depth/restrictions, which have great influence on plant growth and development. Bulk density can be changed by management practices that affect soil structure and porosity like tillage practices. Moraes *et al*. (2016) after two decades of experimentation observed that conventional tillage (CT) resulted in soil pulverization at 0–0.10 m depth, leading to lower D_b and higher macroporosity compared to the other soil tillage systems. Similar treatment differences were confirmed earlier by Ozpinar (2010), Kahlon (2014), Khan *et al*. (2015), Meidani (2014), Parvin *et al*. (2014) and Alizadeh and Allameh (2015).

3.4 Porosity (%) of soil

At 20 DAS, deep tillage treatments (i.e. PTR and PTtB) significantly improved soil porosity (57.95 % each) as compared to initial value of 50.57%. Significantly lowest porosity (55.30%) was registered with treatment BR; followed by treatments HR and ZT with common value (56.06%) of porosity. Moderate tillage treatments TR and TBR recorded the porosity value in the range of 56.44 to 57.20 per cent, being statistically similar to each other. Similar pattern of treatment differences were observed at 40 and 60 DAS. However, at 80 DAS, treatment PTR recorded significantly highest value (55.30%) of porosity. It was closely followed by treatment PTtB. At harvest, deep tillage treatment PTtB reported to be significantly superior with porosity value of 54.55%. and closely followed by treatments of PTR and TtBR. It appears from the results, that the depth of tillage has a pronounced effect on porosity. Reduction in bulk density, improvement in mean weight diameter and reduced soil strength with treatment PTtB may fortuitously enhanced soil physical properties including porosity. Conversely, rototill and blade harrow treatments of BR and HR did not improved the status of P_t at the depth of 0-15 cm, likely due to subsequent soil compaction resulting from reduced soil moisture content. Polat *et al*. (2006) also observed higher BD and lower porosity with rotary-tiller and roller treatments as compared to other moderately deep tillage methods. Similar results were confirmed by Ozpinar and Cay (2005), Polat *et al*. (2006), Ozpinar, S., (2010), Meena *et al*. (2011), Kahlon (2014), Khan *et al*. (2015), and Parvin *et al*. (2014).

3.5 Grain yield

The results (Fig.-1) revealed that use of deep treatments (PTtB and PTR) recorded significantly highest seed yield and on other side zero tillage treatment (ZT), produced lowest grain yield (1072 kg ha^{-1}). It is noteworthy to mention that moderate tillage treatment (TR, TBR and TtBR) being statistically similar with each other, also found superior over zero and shallow tillage treatments. The adequate plant growth with deep tillage treatments (PTtB and PTR) may be due to prolific root growth, thereby enhanced absorption of minerals to nourish aerial plant part, and thereby higher production of photosynthates and metabolites, its efficient diversion towards the reproductive organs, resulting in higher gain yield (Khedkar and Deshmukh, 2018; Kumar et al., 2021). The lower gain yield with zero tillage and shallow tillage treatments could be due to the lower values of plant growth and yield contributing characters. Meshram *et al.* (2019), Alizadeh and Allameh (2015), Gholami *et al*. (2014), Din *et al*. (2013), Khedkar and Deshmukh (2018), reported the highest seed yield in deep tillage treatment of mouldboard plough plus rotavator. On other side Parvin *et al*. (2014) revealed that shallow tillage give higher yield than in mouldboard ploughing. Mukesh *et al*. (2013) also noted that grain yields under no-tillage were equal to those obtained with deep tillage.

4. CONCLUSION

The soil physical properties like infiltration rate, bulk density, porosity, soil moisture content and grain yield of soybean were significantly improved with the deep tillage treatments 1Ploughing + 2tyne harrow + 1blade harrow and 1Ploughing + 1tyne harrow + rotavator operation. Whereas lowest improvement in above mentioned parameters was noted with no till and shallow tillage treatments. Thus, it can be concluded from the aforesaid interpretation of results that conventional tillage practice of 1Ploughing + 1tyne harrow + rotavator operation was found to be the most feasible preparatory tillage system under the condition of *Vidarbha* region of Maharashtra as compared to No tillage or shallow tillage.

REFERENCES

Ahuchaogu, I., Etim, I., and Etuk, A. (2015). Research Paper Effects of Tillage Methods on Soil Inflitration Rate in Uyo, Nigeria. *Cont. J. Eng. Sci*, *10*: 10-20.

Alizadeh, R. M., and Allameh, A. (2015). Soil properties and crop yield under different tillage methods for rapeseed cultivation in paddy fields. *Journal of Agricultural Sciences (Belgrade)*, *60*(1): 11-22.

Anonymous (2019). www.sopa.org

Barua, N.G., Bora, P.K., Kurmi, K., Karmakar, R.M., and Pathak, P.K. (2014). Effect of tillage on soil moisture and energy conservation in production of toria in an inceptisol of Assam. *Indian Journal of Dryland Agricultural Research and Development*, *29*(2): 78-82.

Busari, M.A., Kukal, S.S., Kaur, A., Bhatt, R., and Dulazi, A.A. (2015). Conservation tillage impacts on soil, crop and the environment. *International soil and water conservation research*, *3*(2): 119-129. https://doi.org/10.1016/j.iswcr.2015.05.002.

Chen, G., and Weil, R.R. (2011). Root growth and yield of maize as affected by soil compaction and cover crops. *Soil and Tillage Research*, *117*: 17-27. https://doi.org/10.1016/j.still.2011.08.001.

Chorey, A.B., Dhage, S.J., Darekar, N.K. and Hedao, V.D. (2020). Effect of various Tillage

Practices on Soybean Productivity and Soil Moisture Dynamics under Rainfed Condition. *International Journal of Microbiology and Applied Science,* Special Issue-11: 3231-3236.

Connor, D.J. and Mínguez, M.I. (2012). Evolution not revolution of farming systems will best feed and green the world. *Global Food Security*, *1*(2): 106-113. https://doi.org/10.1016/j.gfs.2012.10.004.

De Moraes, M.T., Debiasi, H., Carlesso, R., Franchini, J.C., da Silva, V.R., and da Luz, F.B. (2016). Soil physical quality on tillage and cropping systems after two decades in the subtropical region of Brazil. *Soil and Tillage Research*, *155*: 351-362.

Dubois, O. (2011). The state of the world's land and water resources for food and agriculture: managing systems at risk. Earthscan, London.

Foley, J.A., Ramankutty, N., Brauman, K.A., Cassidy, E.S., Gerber, J.S. and Johnston, M., *et al*,. (2011). Solutions for a cultivated planet. *Nature*, *478*(7369): 337-342. https://doi.org/10.1016/j.iswcr.2015.05.002.

Franchini, J.C., Debiasi, H., Junior, A.A.B., Tonon, B.C., Farias, J.R.B., de Oliveira, M.C.N. and Torres, E. (2012). Evolution of crop yields in different tillage and cropping systems over two decades in southern Brazil. *Field Crops Research*, *137*: 178-185. https://doi.org/10.1016/j.fcr.2012.09.003.

Gholami, A., Asgari, H.R. and Zeinali, E. (2014). Effect of different tillage systems on soil physical properties and yield of wheat (Case study: Agricultural lands of Hakim Abad village, Chenaran township, Khorasan Razavi province).

Gholizadeh, A., and Kopačková, V. (2019). Detecting vegetation stress as a soil contamination proxy: A review of optical proximal and remote sensing techniques. *International Journal of Environmental Science and Technology*, *16*: 2511-2524.

Karuma, A., Mtakwa, P., Amuri, N., Gachene, C.K., and Gicheru, P. (2014). Tillage effects on selected soil physical properties in a maize-bean intercropping system in Mwala District, Kenya. *International scholarly research notices*, 1: 497205.

Kahlon, M.S. (2014) Soil physical characteristics and crop productivity as affected by tillage in rice-wheat system. *Journal of Agric Sci*; 6 (12)..

Khan, N., Usman, K., Yazdan, F., Din, S.U., Gull, S., and Khan, S. (2015). Impact of tillage and intra-row spacing on cotton yield and quality in wheat–cotton system. *Archives of Agronomy and Soil Science*, *61*(5): 581-597.

Khedkar, S., and Deshmukh, M.R. (2018). Effect of rotavator based tillage systems on soil physical properties in vertisols of central India. *Multilogic in Science, 7*: 218-223.

Khedkar, S., and Deshmukh, M.R. (2018). Effect of rotavator based tillage systems on soil physical properties in vertisols of central India. *Multilogic in Science, 7:* 460-465.

Maharjan, G.R., Prescher, A.K., Nendel, C., Ewert, F., Mboh, C.M., Gaiser, T., and Seidel, S.J. (2018). Approaches to model the impact of tillage implements on soil physical and nutrient properties in different agro-ecosystem models. *Soil and Tillage Research*, *180*: 210-221. https://doi.org/10.1016/j.still.2018.03.009.

Martins, R.N., Portes, M.F., e Moraes, H.M.F., Junior, M.R.F., Rosas, J.T.F. and Junior, W.D.A.O. (2021). Influence of tillage systems on soil physical properties, spectral response and yield of the bean crop. *Remote Sensing Applications: Society and Environment*, *22*: 100517.

Meidani JA (2014) Effects of tillage practices on soil physical properties and yield indexes of wheat in wheat-safflower rotation. Trends in life Sci Vol-3 Special Issue- 2 ISSN: 2319-4731 (p); 2319–5037 (e).

Meshram, D.D., Deshmukh, M.R. and Gabhane A. R. (2019). Effect of various tillage management practices on soil bulk density, penetration resistance and yield of soybean (*Glycine max*). *International Journal of Chemical Studies*, *7*(3): 1306-1312.

Mukesh, S., Vijaya, R., and Anil, K. (2013). Effect of using rotavator on soil properties and crop: a review. *Annals of Agri Bio Research*, *18*(3), 356-359.

Ozpinar, S. (2010). Changes in soil physical properties in response to maize tillage management on a clay loam soil. *Philipp Agric Scientist*, *93*(3): 337-345.

Özpinar, S., and Çay, A. (2005). Effects of minimum and conventional tillage systems on soil properties and yield of winter wheat (*Triticum aestivum* L.) in clay-loam in the Çanakkale region. *Turkish journal of agriculture and forestry*, *29*(1): 9-18.

Parvin, N., Parvage, M.M., and Etana, A. (2014). Effect of mouldboard ploughing and shallow tillage on sub-soil physical properties and crop performance. *Soil science and plant* *nutrition*, *60*(1), 38-44.

Paudel, B., Radovich, T.J., Chan-Halbrendt, C., Crow, S., Tamang, B.B., Halbrendt, J. and Thapa, K. (2014). Effect of conservation agriculture on maize-based farming system in the mid-hills of Nepal. *Procedia Engineering*, *78*, 327-336.

Polat R, Saglam R, Aydemir S and Qikman A (2006) Effects of different tillage methods on soil physical properties under second crop sesame in the Harran Plain, Southeast Turkey. *Asian J Pl Sci* 5 (4): 613-618.

Dias, P., Secco, D., Santos, R.F., Bassegio, D., Samways Santos, F., and Arbex Silva, P.R., *et al*., (2015). Soil compaction and drought stress on shoot and root growth in crambe ('*Crambe abyssinica*'). *Australian Journal of Crop Science*, *9*(5): 378-383.

Rockström, J., Williams, J., Daily, G., Noble, A., Matthews, N., Gordon, L. and Smith, J. (2017). Sustainable intensification of agriculture for human prosperity and global sustainability. *Ambio*, *46*(1): 4-17.

Stoate, C., Baldi, A., Beja, P., Boatman, N.D., Herzon, I., Van Doorn, A., and Ramwell, C., *et al*., (2009). Ecological impacts of early 21st century agricultural change in Europe–a review. *Journal of environmental management*, *91*(1), 22-46. https://doi.org/10.1016/j.jenvman.2009.07.005

Ud Din, S., Ramzan, M., Rahman, M.U., Khan, R., Waqas, M., and ud Din, I. (2013). Efficacy of tillage and mulching practices for weed suppression and maize yield under non-irrigated condition. *Pakistan Journal of Weed Science Research*, *19*(1), 71-78.

Table 1. Rate of infiltration (cm hr^{-1}) as affected by various tillage practices

Treatment	**Initial and Final Rate of Infiltration (cm hr^{-1})**	
	At sowing	**At harvest**
ZT	7.21	6.00
HR	7.64	5.74
BR	7.58	5.42
TR	7.94	6.67
TBR	7.89	6.46
TtBR	8.03	6.83
PTR	8.52	7.09
PTtB	8.60	7.20

SE (m)±	0.186	0.127
CD at 5%	0.581	0.397
GM	7.93	6.43

Table 2. Effect of tillage treatments on soil moisture content (%) at 0-30 cm depth

Treatment	**Periodical Soil moisture content (%) at the depth of 0-30 cm**				
	20 DAS	**40 DAS**	**60 DAS**	**80 DAS**	**At harvest**
ZT	35.44	31.27	19.27	25.85	33.42
HR	34.27	31.17	19.19	25.13	33.17
BR	34.15	30.49	19.11	24.08	33.75
TR	34.56	33.17	21.16	27.64	34.55
TBR	34.87	33.48	21.19	28.15	34.64
TtBR	35.76	33.64	21.77	29.08	34.08
PTR	34.91	33.81	23.17	29.58	34.46
PTtB	35.73	33.73	23.48	29.54	34.28
SE (m)±	0.551	0.345	0.409	0.456	0.476
CD at 5%	NS	1.035	1.227	1.369	NS
GM	34.96	32.60	21.04	27.38	34.04

Table 3. Bulk density (Mg m^{-3}) of soil at the depth of 0-15 cm as affected by various tillage practices

Treatment	**Periodical bulk density (Mg m^{-3}) at the depth of 0-15 cm**				
	20 DAS	**40 DAS**	**60 DAS**	**80 DAS**	**At harvest**
ZT	1.16	1.22	1.38	1.34	1.29
HR	1.16	1.21	1.36	1.31	1.27
BR	1.18	1.24	1.40	1.36	1.31
TR	1.13	1.14	1.31	1.25	1.25
TBR	1.15	1.16	1.32	1.27	1.26
TtBR	1.12	1.14	1.29	1.24	1.22
PTR	1.11	1.12	1.24	1.18	1.22
PTtB	1.11	1.11	1.24	1.19	1.20
SE (m)±	0.01	0.01	0.01	0.01	0.01
CD at 5%	0.02	0.03	0.04	0.04	0.02
GM	1.14	1.17	1.32	1.27	1.25
Initial	1.34				

Table 4. Porosity (%) of soil at the depth of 0-15 cm as affected by various tillage practices

Treatment	**Periodical soil porosity (%) at the depth of 0-15 cm**				
	20 DAS	**40 DAS**	**60 DAS**	**80 DAS**	**At harvest**
ZT	56.06	53.79	47.73	49.24	51.14
HR	56.06	54.17	48.48	50.38	51.89
BR	55.30	53.03	46.97	48.48	50.38
TR	57.20	56.81	50.38	52.65	52.65
TBR	56.44	56.06	50.00	51.89	52.27
TtBR	57.58	56.81	51.14	53.03	53.79
PTR	57.95	57.58	53.03	55.30	53.79
PTtB	57.95	57.95	53.03	54.92	54.55
SE (m)±	0.08	0.11	0.12	0.14	0.08
CD at 5%	0.24	0.33	0.37	0.42	0.24
GM	56.82	55.78	50.10	51.99	52.56
Initial	50.57				

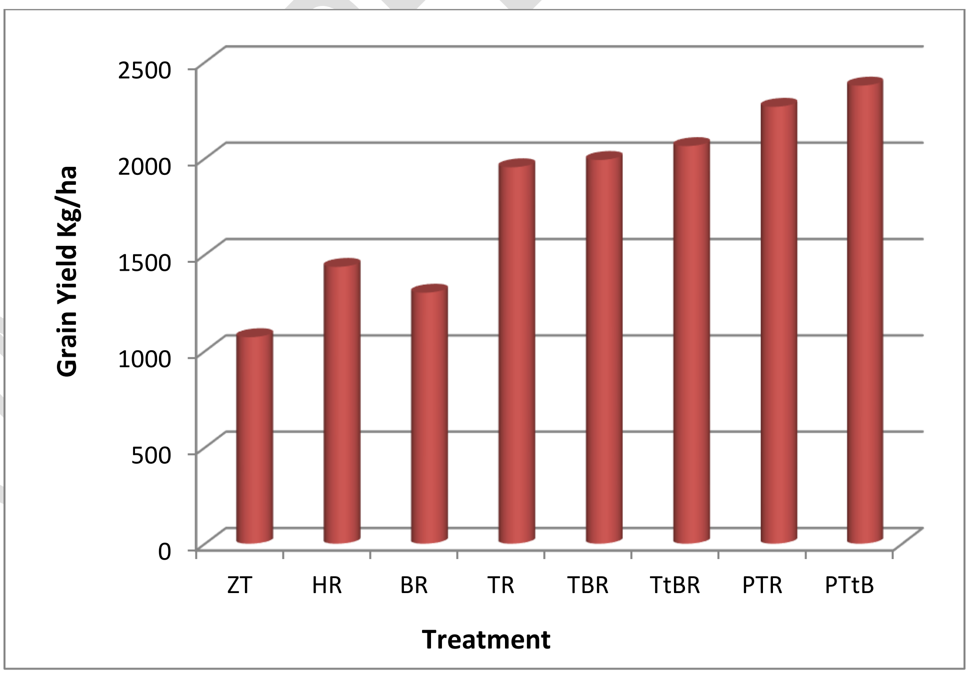

Fig1. Grain yield (Kg ha^{-1}) of soybean as affected by various tillage practices