6. Conclusions

In order to address the findings of the present investigation entitled “Studies on various changes in biochemical, qualitative and quantitative parameters in conservation agriculture based wheat production”, following conclusions can be drawn:

- Physical properties of soil in term of bulk density decreased at 0-15 cm depth by the adoption of conservation agriculture (CA). Due to CA, there was no effect on soil texture as it cannot change in a short time frame.
- Chemical properties of soil, such as pH decreased from alkaline to neutral at both depth 0-15 and 15-30 cm due to CA adoption. CA adoption can increased EC more at 15-30 cm depth as compared to 0-15 cm depth. SOC increased at surface soil 0-15 cm depth as compared to sub-surface 15-30 cm depth.
- CA applications improved availability of N, P and K in both surface and subsurface depths (0-15 and 15-30 cm). Results suggest that CA technology can enhance available nutrient quantity and quality of soil.
- DTPA-Fe content in soil increased due to CA practices, but in conventional agriculture, it recorded a higher increment than CA at both depths. In CA application, DTPA-Zn was more in soil at surface soil than sub-surface soil. DTPA-Mn availability slightly reduced with duration in CA application at surface soil, but it increased at sub-surface soil. DTPA-Cu declined with the adoption of CA at both depths. Results suggests that there is need to apply appropriate micronutrient sources with CA adoption.
- CA practices slightly increased exchangeable Ca at surface soil but it decreased at subsurface soil. Exchangeable cation Mg and Na at surface soil also decreased due to CA practices, but Mg concentration in sub-surface soil increased and Na concentration shows vice-versa relation to Mg in CA.
- Results of fractionation of N when compared with CA to conventional agriculture, total-N and total org-N, increased in CA practices for both depth,
while in conventional agriculture decreased total-N and total org-N for sub-surface depth. NH$_4$-N and NO$_3$-N reduced in CA for both depths.

✓ Findings of carbon fractionation in soil shows that TOC and POC may enhance at both depth due to CA practices. Very labile oxidizable carbon (fraction I) decreased due to adoption of CA, and labile C (fraction II), less labile C (fraction III) and non-labile C (fraction IV) concentration in soil increased due to CA practices for surface and sub-surface soil. Increment in Fraction III and Fraction IV are an important for increase of C sequestration in soil.

✓ Total P, loosely bound P and Ca-bound P and total organic P showed significant increase due to CA practice. While other inorganic fraction such as Al-bound P, Fe-bound P and reductant P reduced due to CA adoption.

✓ Potassium fractionation of soil showed an increase in water soluble-K, nitric acid-K, available-K, exchangeable-K, non-exchangeable-K, total (HF)-K of surface soil (0-15 cm depth) due to CA, while lattice-K fraction (fixed form) in soil slightly reduced under CA practices.

✓ Biological properties of soil such as soil MBC, DHA and PMN was higher due to zero-tillage, diversified crop rotation and residue retention undertaken in CA practices and thus could be useful for the restoration of biological fertility of soil.

✓ Attributes in flag leaf of wheat during grain filling stage of wheat under CA practices may induce reactive oxygen species (ROS) activity in the plant cell, as a result there was an increase of hydrogen peroxide (H$_2$O$_2$). It because the plants faces stress condition. Overproduction of H$_2$O$_2$ in plant cell accelerates antioxidant defense system. Hydrogen peroxide is being scavenged by reducing agents such as antioxidant enzymes

✓ The antioxidant enzymes namely APX, CAT, GR, SOD and POX activities increase in the plant cell and it is important for protecting plant against stress induce ROS. It suggests that higher level ROS detoxifies by the antioxidant defense system and mitigate stress impact caused by the environment factor. It may be terminal heat, drought or any other unknown factor causing stress.
Proline content and protein concentrations decreased due to CA practices as compared to conventional agriculture. In actual condition, proline may be an important stress biomarker and become increasingly important for future investigations on stress thresholds for productivity and product quality. The enhancement of protein content in current farmer’s practices may be because of high amount of inorganic fertilizer such as urea, and there may some relationship for its mobilization to the grain.

Gradual increase in LOX activity during the CA practices suggested a relationship of this enzyme to the agricultural management. The results obtained in this investigation may be important for a more understanding of the behavior of crop to agricultural practices and prediction of quality of the products.

The total chlorophyll, chlorophyll a and total carotenoids in CA practices increased. It is a good indicator for crop health. However, chlorophyll b reduced in CA as compared to conventional practices.

Biochemical quantity in grain and straw of wheat at harvest in term of N, P and K, suggests that the adoption of CA practices enhanced significantly the concentration of total N, P and K in grain and straw and improved its uptake. It can also be concluded that N and P concentration in grain and K concentration in straw was higher in CA practices. Amount of micronutrient in particular Fe and Zn is greater in straw than grain under CA practices. High amount of Fe and Zn along with other nutrient in CA practices is important in residue recycling point of view, which will be released into soil after decomposition and increase again quality and quantity of nutrients.

Yield attributing parameters of wheat such as germination, reduced the number of day. It may be due to sufficient moisture, residue cover and zero-tillage under CA practices. Plant height, number of tillers, grain filling period, maturity period, average spike weight, grain weight per spike and thousand grains weight improved due to adoption of CA practices as compared with conventional agriculture. Finding of these improvement suggests a prediction
of improved quality and quantity of crop yields. It can say that grain and straw yield increased by the conversion of conventional to conservation agriculture.

Over all on the basis of above findings in rice-wheat cropping system, it can be concluded that the replacement of conventional agriculture with conservation agriculture can enhance the soil fertility status and resilience in term of physical, chemical and biological properties along with organic fraction of nutrients and increase crop resilience also through enzymatic and non-enzymatic defense mechanism under climate adversities, increase quality and quantity of crop yield along with well nutritious products, and provide better economic benefits. Conservation agriculture can improve crop resilience in a variety of ways in the extreme events. Even many of benefit points toward the value of adopting conservation agriculture to improve resilience. However, more efforts toward the CA innovations in soil fertility management in particular micronutrient application are needed.