S.K. Singh, T.D. Lama, Anant Bahadur, Paresh Chaukhande, Raghwendra Singh and B. Singh

Conservation tillage is a sustainable way of vegetable production

Conservation tillage practices like minimum tillage, no-tillage or zero tillage have the potential as an energy use and cost-efficient technology in vegetable production, besides improving soil properties and reducing greenhouse gas emission. Such resource conservation technologies, which are components of conservation agriculture are the key to sustainable farming and will help to meet the challenges of achieving food and nutritional security under declining land and water resources, increasing input costs and threats of climate change.

THERE is an urgent need to match vegetable production with increasing population for food and nutritional security. In vegetable cultivation, generally the soil is subjected to intensive primary and secondary tillage operations to prepare a fine seed bed for crop establishment either through seedling transplanting or seed sowing. Intensive tillage not only destroys soil aggregates, soil structure and soil organic matter through oxidation, but also causes loss of soil nutrients and soil degradation through soil erosion. A large volume of scientific and empirical evidences showed widespread deficiency of macro (NPK), secondary (Ca, S, Mg) and micro (Zn, Fe, Mn, etc) nutrients in vegetable crop production. In recent times, escalating input costs including fuel, fertilizer and other inputs is a major concern making farming less remunerative. In vegetable cultivation, a significant portion of energy (25-30%) is being utilized for either field preparation or crop establishment where conventional tillage is followed. The growing concern for improved soil management techniques, demand identification of an environmental friendly and crop yield sustainable system of tillage. Conservation tillage, the most important aspect of conservation agriculture, is thought to take care of the soil health, plant growth and the environment.

Research at IIVR, Varanasi

Considering the facts, IIVR, Varanasi, initiated a long-term trial during 2010-11 on conservation agriculture for production of vegetable crops. The experimental trial conducted consisted of conservation tillage consisting of minimum till (MT), zero till and conventional tillage coupled with residue retention/ removal with different vegetable crops.

CONSERVATION TILLAGE

Conservation tillage is any tillage system that leaves at least 30% of the soil surface covered with crop residue after planting to reduce soil erosion by water. In the broader sense, conservation tillage includes no-tillage, direct drilling, minimum tillage and ridge tillage, and denotes that the practice has a conservation goal. The main principle behind conservation tillage is to minimize disturbance of soil. It forms part of the conservation agriculture practices which aim to achieve the goals of enhanced productivity and profitability while protecting the natural resource and environment. Research reports have identified several benefits of conservation tillage (CT) over conventional tillage with respect to physical, chemical and biological properties of soil as well as crop yields. CT is considered as a suitable technique for soil erosion control, more retention of soil water, and physical protection of soil organic carbon (SOC), productivity enhancement, reduced cost of cultivation and improved economic benefits besides, efficient use of energy and inputs.

Vegetables Under No-tillage

Direct seeded crops such as pea, cowpea, okra, etc. can be sown without tillage after the harvest of previous crop by dibbling manually or with commercially available zero till multi-crop seed drill/planter. Crops like cucurbits, tomato, cabbage, etc. the seedlings can be transplanted in holes opened in the soil with a *khurpi*. Besides, vegetable can also be planted on permanent raised beds following zero tillage. Sowing or transplanting of crops should be done when soil moisture content is appropriate. If there is insufficient soil moisture then irrigation should be applied before harvest of previous crop and sowing/transplanting should be done when the soil moisture reaches an optimum level or after sowing/ transplanting, a light irrigation may be applied. The residues of previous crops should be left on the soil surface as mulch which helps in conserving soil moisture and regulation of soil temperature. Fertilizers can be band placed along the rows beneath the residue or applied during the time of sowing through drill.

Weed Control under No-tillage

Weed control can be achieved through application of

Table 1. Energy-use efficiency and benefit:cost ratio under different tillage management

	Cowpea (summer)		Cowpea (*Kharif*)		Chilli (winter)		Cabbage (winter)		Tomato (winter)	
Treatment	EUE	B:C	EUE	B:C	EUE	B:C	EUE	B:C	EUE	B:C
Conventional tillage	4.55	2.32	4.54	2.58	1.06	1.87	2.42	3.15	2.49	2.73
Conservation tillage	4.93	2.58	5.16	2.85	1.14	1.86	2.70	3.66	2.87	2.79
Residue retention	1.48	2.65	1.54	2.80	0.79	1.97	1.48	3.53	1.34	2.86
Residue removal	8.00	2.24	8.20	2.63	1.40	1.77	3.65	3.28	4.02	2.66

herbicides. Before planting, any existing vegetation can be killed with broad spectrum herbicides like glyphosate. During the crop growth period, specific herbicides should be used to control specific weeds. Care should be taken so that spraying is uniform in the field and always flat fan nozzle should be used. Besides, retaining crop residues as much as possible to fully cover the soil will also help in controlling weeds.

Performance of Conservation Tillage

It was found that during the first year of a tillage experiment, there was significant reduction in tomato yield under conservation tillage as compared to conventional. The third year results showed that there was no significant difference in the tomato fruit yield in conservation tillage and conventional tillage, the mean yield of tomato was equivalent to conventional system. In the subsequent years, it was observed that consistently higher yield was recorded in conservation tillage than conventional tillage, however lower yield was recorded under zero tillage. During the sixth year, 23% higher yield was recorded in tomato in the plots under conservation tillage. Similarly, conservation tillage produced higher yield in summer cowpea, *kharif* cowpea, cabbage, pea and chilli. In vegetable cowpea, at par yields were obtained in zero tillage than under conventional tillage.

The input energy was lower by 16% under zero tillage as compared to conventional tillage. Similarly, input costs in zero tillage were lower by 34% than conventional tillage. Savings in diesel under zero tillage was estimated around 75 lit/ha/yr, corresponding to reduction of 196 kg/ha/yr CO_2 emission. Higher energy-use efficiency as well as benefit to cost ratio is also obtained under zero tillage as a result of reduced input used particularly, energy and capital input and subsequently reduction in input cost (Table 1). Tillage impact on crop yield is related to its effects on root growth, water and nutrient use efficiencies and ultimately the agronomic yield. Conservation tillage improved the water-use and energy-use efficiency in tomato, cabbage, chilli and cowpea.

Crop residue is an important renewable resource. Developing techniques for effective utilization of this vast resource is a major challenge. Improper uses of crop residues (e.g. removal, burning or ploughing under) can aid accelerated erosion, soil fertility depletion and environmental pollution through burning. The principle of conservation tillage involves maintenance of surface soil cover through retention of crop residues achievable by practicing zero tillage and minimal mechanical soil disturbance. Retention of crop residue was found to be highly beneficial and improved the yield of tomato, cabbage, chilli and cowpea. The energy-use efficiency was lower under residue retention due to increased energy input resulting from addition of crop residues.

Conservation Tillage and Soil Properties

Soil physical and chemical properties

Analysis of soil samples collected from the surface layer of 0-15 cm revealed that the soil organic carbon content and carbon management indices were better under conservation tillage as compared to conventional tillage. Besides the total porosity, water holding capacity and available water were higher under conservation tillage. These parameters were further increased due to residue retention as compared to residue removal. Due to retention of crop residue, organic carbon content increased by 15-18% in soil as compared to the field where crop residues were removed.

Soil biological properties

The soil biological property most affected by tillage was SOC content. The soil organic matter content influences to a large extent the activities of soil organism which in turn influence the SOC dynamics. Conservation tillage recorded higher soil organic carbon, microbial biomass carbon and microbial activity. The total microbial activity assessed in terms of fluorescein diacetate hydrolytic activity (FDHA) in the upper 0-15 cm soil layer was 34% higher in conservation tillage (6.03 fluorescein/g soil) as compared to conventional tillage. Addition of crop residues further led to improvement of these parameters. Soil organic carbon and microbial activity is an indicator of soil quality. Higher values of these parameters under conservation tillage and residue retention indicated improvement in soil physical and biological properties leading to better soil health.

SUMMARY

Study conducted at ICAR-IIVR indicated that Conservation Agriculture Technology like conservation or zero tillage and residue retention is a sustainable management strategy in vegetable production system for improving soil quality and crop productivity, attaining higher energy-use efficiency and profitability, and improving carbon sequestration to mitigate climate change.

For further interaction, please write to:
Dr S.K. Singh, ICAR-Indian Institute of Vegetable Research, Post Bag No. 01 P.O. Jakhini, Shanshashapur, Varanasi 221305.