No-till lentil: An option for profitable harvest in dry areas

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Abstract: No-till lentil holds promise for minimizing soil and crop residue disturbance, controlling soil evaporation, minimizing erosion losses, sequestering carbon and reducing energy needs. These effects reduce overall cost of production while improving yields and returns to farmers. No-till planters have been developed that cause minimal disturbance to the soil and previous crop residues while placing the seeds in an optimum position for germination and emergence. Timely planting of lentil under no-till systems in rainfed lowland ecologies help the crop to escape negative effects of terminal water stress and rising temperatures. No-till technology has been demonstrated at farm levels, resulting in adoption by farmers in some regions. The main advantages are cost savings, flexibility in planting times and reduced water requirements. Problems with adoption relate to weeds, crop establishment and availability of no-till seeders. Varieties suitable to no-till are also needed. With awareness and knowledge of a package of practices, these issues can be overcome for widespread adoption of this cost saving and environmentally friendly technology.

Key words: direct seeding, lentil, moisture utilization, reduced tillage

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Lentil (*Lens culinaris* ssp. *culinaris*) is an important food legume crop with various uses as food and fodder due to its protein rich grains and straw. Globally, it is cultivated on 3.85 million ha area with 3.59 million tonnes production. The major geographical regions of lentil production are South Asia and China (44.3%), Northern Great Plains in North America (41%), West Asia and North Africa (6.7%), Sub-Saharan Africa (3.5%) and Australia (2.5%). South Asia grows lentil on 1.8 million ha area with 1.1 million tonnes production exclusively as a post-rainy season crop on residual moisture whereas West Asia and North Africa (WANA) with Turkey, Syria, Iran and Morocco as main producers grow winter and spring planted lentil on 0.39 m ha with 0.19 million tonnes production. In the Sub-Saharan Africa, Ethiopia and Eritrea are the major lentil producers with 0.10 million tonnes production. In recent years, area under lentil has expanded in the Northern Great Plains of North America (Canada and USA) which produces 1.15 million tonnes of lentil and has emerged as the foremost production base. In these regions, lentil is grown as rainfed crop under various tillage systems including conventional as well as zero tillage. Production cost play an important role in area allocation under a particular crop. For further expansion of area under lentil, its economic competitiveness needs to be improved by reducing production cost through adoption of various resource conservation technologies. No till or zero tillage (ZT) is an important component of conservation agriculture to produce crops at low cost with profound effect on natural resources such as water and soil. This system is very effective in minimizing soil and crop residue disturbance, controlling soil evaporation, minimizing erosion losses, sequestering carbon in soil and reducing energy needs.

No till (direct seeding without tillage or zero tillage) of lentil into standing stubble left after cereal (wheat or barley) harvest is becoming an option in the developed countries where soil erosion is a problem (1, 12, 14). In the no-till system of planting, seeds are placed manually or mechanically with a special seeder by opening a narrow slit in soil without much soil disturbance. The key objective is to tap residual soil moisture and leftover fertility of previous crop by the succeeding lentil crop. No till system is recommended in the USA for autumn sown lentil as a means of conserving soil moisture and to provide some surface protection to reduce winter injury to the developing lentil plants (2). No-till lentil has found favor in recent years in Great Plains of the USA, Canada and Australia where farmers grows lentil on large areas as a rainfed crop and derive benefits from diversification and export opportunities. In South Asia, the seeds of lentil are traditionally broadcasted in the standing rice crop nearing maturity or after the monsoon in fallow land without any tillage to exploit residual moisture for germination and stand establishment. This age-old practice of surface planting popularly known as paira or utera cultivation in India, Bangladesh and Nepal, is a true form of no-till lentils. The no-till method of planting, however, requires one time investment to procure suitable zero-till machine.

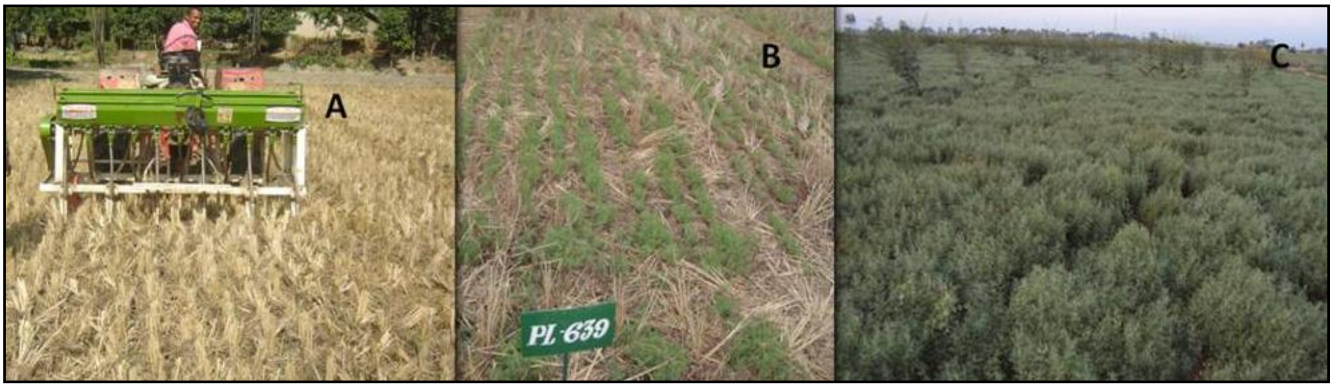
Zero till drill seeder

Planting of no-till lentil requires a special planter called zero till seeder which is similar to conventional seeder except for the furrow openers. The zero-till seeder holds a narrow inverted 'T' type furrow opener for seed and fertilizer placement in unprepared soil with anchored crop residues. However, double disk openers or star wheels are used to facilitate seeding in fields with loose crop residues. The zero till machine also varies with seed metering system. In zero till drill/seeder with fluted roller seed metering system, seeds flow continuously while seeding without maintaining plant spacing whereas zero-till planters can maintain row to row and plant to plant spacing (3). A zero till drill/planter comes with a depth control wheel or other depth control mechanisms which is very important to place seeds at uniform depth for ensuring better stand establishment. No-till system saves about 20-35 US$/ha in Indian conditions in addition to other benefits such as reduced seed rate, better use of applied fertilizers, and timely sowing (normally 5-20 days early seeding due to eliminating tillage). Timely planting of lentil under no-till system in rainfed lowland ecologies help escape negative effects of terminal water stress and rising temperature.

Benefits of no-till lentils

Lentil is an important component of no-till system because it provides an inexpensive source of soil N for subsequent crops, thrives well on less soil water, and breaks the life cycle of crop pests, which can be a problem in continuous cereal cropping systems. Research on various aspects of no-till suggests that growing crops under no-till not only increased yield but also increased other rotational benefits. It increases organic matter content of soil and microbial biomass as compared to conventional tillage (4).There are reports of higher uptake of N and P by lentil with one ploughing as compared with zero tillage on sandy loam soils of Agra in India (15). Loss of organic matter after tillage is particularly severe in the Tropics (6). The zero tillage with better crop residue management can immensely help sequestering carbon in degraded lands. An increase of 1 ton of soil carbon pool of degraded land soils may increase crop yield by 20 to 40 kg/ha for wheat, 10 to 20 kg/ha for maize and 0.5 to 1 kg/ha for cowpeas (9).

No-till method lowers mineralization and nitrification rates, and increases immobilization of N (16). This leads to a decrease in available N, which stimulates nitrogen fixation of legumes planted in no-till soil. Nitrogen fixation is reported to increase by 10% in lentil after four years in zero tillage in a semi-arid environment (16). Tillage practices can also affect nitrous oxide (N_2O) emissions, a powerful greenhouse gas produced by soils, fossil fuel burning and fertilizers. For example, increasing numbers of growers have adopted no-till practices to reduce erosion and improve soil tilth. In some areas in North America, no-till slows the decomposition of crop residues, and for this reason, no-till systems have been promoted as carbon sinks. But in certain soils, the higher water content in no-till systems may cause higher N_2O emissions than conventional tilled soil, partially offsetting the beneficial greenhouse gas mitigation of no-till. No-till still appears to be creating a net sink and not a source of greenhouse gases, on balance (16). In the system experiments, the no-tilled plots had an average of 35 mm additional soil water at sowing which can be converted into fixed N at the rate of 0.5-0.8 kg/mm (8).



Picture 1: No-till lentils; Planting in rice residues (A), cultivar PL 639 (B) and Farmer's field in eastern IGP (C)

Reducing tillage and retaining crop residues greatly help in reducing wind and water erosion. Studies conducted at the University of Idaho during 2004-06 concluded that lentil can be economically cultivated in no-till system (7). There could be advantage to no-till in some years if available soil moisture is limited. Other studies have shown that the benefit of legumes including lentil in no-till systems occurs because of the extra soil moisture conserved from leaving standing stubble over the winter, increasing snow trapping and moisture conservation and the improved microclimate during the growing season (13). Because of the low residue produced by lentil, it does not necessarily prevent erosion when used in no-till systems, at least not in comparison with soil residues from no-till wheat. Thus, it is important to maximize conservation of lentil residue when grown in highly erodible soils.

Conservation agriculture affects the plant growth environment and associated patho-systems. Evaluation of 10 lentil genotypes under zero and conventional tillage systems at ICARDA showed no significant difference on disease intensity of fusarium wilt between tillage systems (11). However, genotypic differences were noticed for wilt incidence under both the systems without interaction effect. Wilt incidence among lentil genotypes ranged from 1 to 46%, with eight genotypes showing less than 10% mortality under no-till system (Fig. 1). Similarly, a study conducted in Canada during 1996 to 1999 also revealed that the tillage management is unlikely to have an effect on severity of ascochyta blight except in rotation with short re-cropping intervals (5).

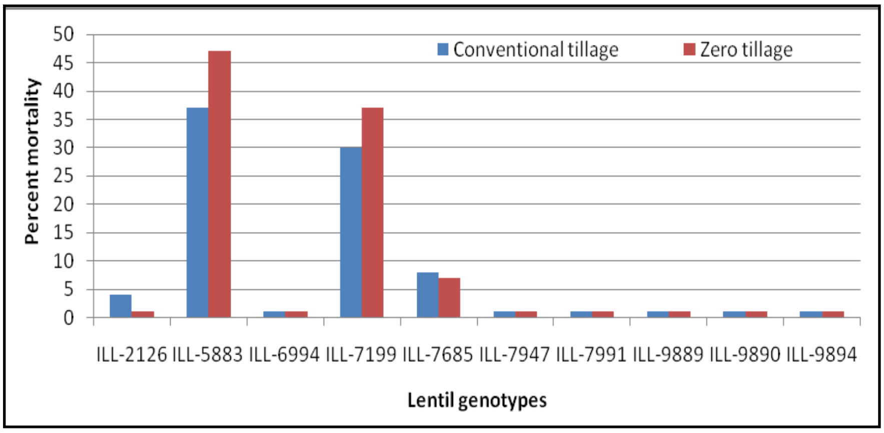


Fig. 1. Effect of tillage on percent wilt mortality of lentil genotypes

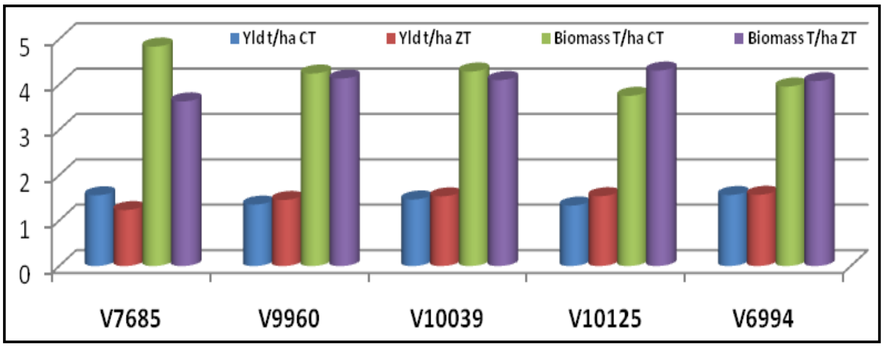


Fig. 2. Grain and biomass yield (t/ha) of top 5 varieties of lentil at Arnaz 2009-10

Lentil yields under no-till system

Experiments with 10 varieties of lentil at Arnaz (Syria) during 2010 (300 mm precipitation) revealed that the grain yield of lentil varied between 990 and 1560 kg/ha with a mean of 1330 kg/ha under conservation (one sweep cultivation was applied a week before seeding) tillage whereas it ranged between 1110 and 1570 kg/ha with an average of 1380 kg/ha under no-till system. The grain yield of most of the varieties was equal or higher under no-till system (Fig. 2). Two varieties, ILL10039 and ILL10125 gave 1540 kg/ha grain yield under no tillage. In a three-year trial conducted with a number of lentil varieties under conventional and no-till conditions at the University of Idaho revealed that the average yields of no-till lentils were 95, 102 and 128% of conventional tillage during 2004, 2005 and 2006, respectively (7). However, the performance of varieties was not consistent in response to tillage and the influence of tillage was driven by weather conditions. When moisture was limiting there was greater advantage of no-till. However, no-till was always effective with the use of crop residue as mulch (10).

In a contrasting environment of eastern Indo-Gangetic plains (IGP) with high rainfall, farmers grow local landraces of lentil at relatively high seed rate (100-150 kg/ha) to offset seed mortality due to soil-borne pathogens. Results of farmers' participatory trials conducted in the eastern IGP revealed that no-till lentil with reduced seed rate (30 kg/ha) sown 5-6 cm deep helps in reducing wilt incidence besides improving grain yield (1.53 t/ha) over conventional tillage (1.22 t/ha) and surface seeding (0.91 t/ha) (Fig. 3). In adaptive trials conducted at four locations in eastern IGP on evaluation of cultivars and economizing seed rate for surface seeding of lentils, it was observed that reducing seeds rate up to 25 kg/ha did not affected yields significantly (Fig. 4). Newly released cultivar HUL 57 and Arun yielded 40 per cent higher than farmers' grown variety PL639 (3).

Perspective

The no-till lentil technology has been demonstrated at farm levels, resulting in its adoption by farmers in some regions. The main driving forces behind the adoption at farm level were cost saving, flexibility in planting time and less water requirement. However, some technical problems with large-scale adoption of no-till system are associated with weed menace and crop establishment besides availability of zero-till seeders and development of improved varieties suitable for no-till system. Some of the traits such as early growth vigor, fast ground cover and high biomass with herbicide tolerance are desirable in no-till lentils as these traits would help lentil plants to compete with weeds as weed management emerges as a key issue for success of no-till lentils. The minimal soil disturbance under no-till ensures that most weed seeds are left on the soil surface and emerge as a major production constraint. Generally, the weed flora observed in lentil is complex including grassy, broadleaf and sometimes sedges. Weeds like *Vicia sativa, Chenopodium album* are prolific seed producers, and can drastically reduce the yields. We have limited pre- and post-emergence herbicide molecules to control the complex weeds in lentils. However, herbicides like pendimethalin, trifluralin, alachlore and fluchloralin have been recommended as pre-emergence and quizalafop, imazethapyr and aclonifen as post-emergence herbicides. However, when a field is infested with germinating or established weeds at planting time, it is always better to use glyphosate to control weeds and eliminate weed complex at early crop stage. Multi-location experiments carried out under the All India Coordinated Research Project on MULLaRP crops showed that pre-emergence application of pendimethalin @ 1 kg/ha and post-emergence application of Imazethapyr @ 37.5 g/ha at 30 days after sowing were found effective in managing weeds in lentil fields with positive effect on grain yield. In Canada, commercial production of new varieties with imidazolinone resistance (Clearfield® Lentil) has helped to control weeds through post-emergence application of selective herbicides. Similarly, lack of knowledge in machinery operation leads to poor seed distribution and improper stand establishment. However, with awareness and knowledge of package of practices, these issues can be tackled for widespread adoption of this cost-saving technology. ■

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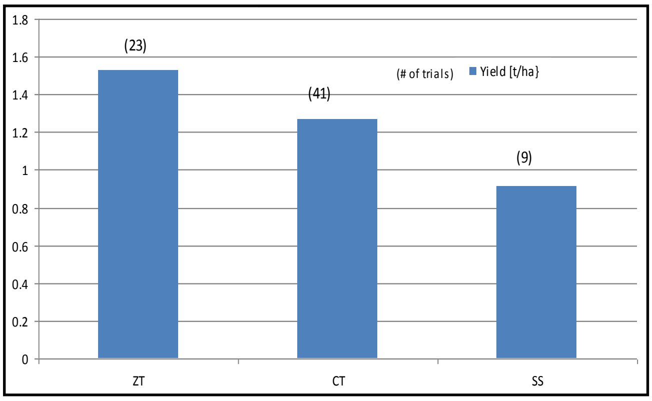

Fig. 3: Effect of tillage methods on lentil yield in farmers' participatory trials conducted in India during 2009-10

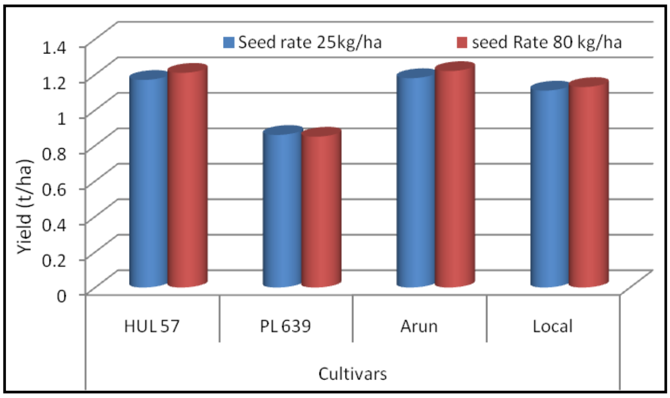

Fig 4: Effect of seed rate on grain yield under surface seeded lentil cultivars in India during 2009-10