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Review on Agronomic Practices for Improving Production and Productivity of Lentil in Ethiopia

Getahun Mitiku
Land and Water Resources Research Process, Holeta Agricultural Research Center, P.O.Box 32, Holeta, Ethiopia

Abstract
Lentil is among the most important cool season food legumes cultivated in rotation with cereal crops in the central highlands of Ethiopia. Poor agronomic practices are among the major constraints limiting the production and productivity of this crop. Improving agronomic practices such as seedbed preparation, sowing date, seed rate, weed control and pest management will enhance the production and productivity of lentil. Concerning sowing date, it varies with the pattern and total amount of rainfall, altitude, soil type and maturity period of the specific crop cultivar but in general, late June to mid July is the recommended time for planting lentil in the central highlands of Ethiopia. A seed rate of 50-65 kg ha^{-1} for small seeded lentil, 65-80 kg ha^{-1} for medium and up to 120 kg ha^{-1} for large seeded lentil cultivars were recommended in Ethiopia. For lentil, two hand-weeding within four to eight weeks after seedling emergence was recommended to control weed. Though not common practice, application of herbicides was also recommended for weed control in lentil.
Keywords: Agronomic practices, Cultivar, Ethiopia, Lentil

1. Introduction

Lentil is a self pollinating diploid (2N= 14 chromosomes) annual winter crop and belonging to the genus Lens of the Viceae tribe in the *Legumnosae* (*Fabaceae*) family, commonly known as the legume family. The cultivated lentil, *Lens culinaris spp. culinaris*, has two varietal types: small seeded (microsperma) and large seeded (macrosperma)

The center of origin of *L. culinaris* is the Near East and was first domesticated in the Fertile Crescent around 700BC (Zohary, 1972). According to Cubero (1981), lentil is first spread to the Nile from the Near East, to Central Europe and then the Indian Subcontinent and the Mediterranean Basin by the end of Bronze Age. Ethiopia is amongst the centers of diversity for lentil (Edossa Fikiru et al., 2007). Lentil is currently an important pulse crop grown widely throughout the Indian Subcontinent, Middle East, Northern Africa, Southern Europe, North and South America, Australia and West Asia (Ford and Taylor, 2003). Ethiopia is also one of the major lentils producing countries in the world and the first in Africa (FAOSTAT, 2006).

In Ethiopia, lentil is grown for human consumption as a rich source of protein (23-24%) (Addise and Asfaw, 1993) and therefore, may correct important amino acid deficiencies of cereals when used in mixture with cereal crops. Its seed also a rich source of minerals and vitamins for human nutrition and the straw is a valuable animal feed. It is a cash crop that has highest price in domestic market compared to all other food legumes and cereals (Geletu et al., 1996). It is also an important export crop for Ethiopia. The crop is generally grown in rotation with cereals to break cereal disease cycles and to fix atmospheric nitrogen, thus reducing the demand of other cereal crops for nitrogen fertilizers.

The objective of this paper is to review major agronomic practices for improving production and productivity of lentil.

2. Lentil description

Lentils are slender, semi-erect annuals, usually between 30 and 45 cm (12–18 inches) tall. Individual plants may vary from single stems to vigorous, bushy forms in dense or sparse stands. The pinnate leaves are relatively small compared with the trifoliolates of soybean and *Phaseolus* beans and may contain as many as 14 sessile, ovate, elliptic, obvate, or lanceolate leaflets, each about 1–4 cm (0.5–1.5 inches) long. Each leaf is subtended by two small stipules and may or may not terminate in a tendril.

3. Origin and distribution

Lentils were originated in the Near East and rapidly spread to Egypt, central and southern Europe, the Mediterranean basin, Ethiopia, Afghanistan, India and Pakistan, China and later to the New World including Latin America (Cubero, 1981). It is probably the oldest of grain legumes to be domesticated (Bahl et al., 1993). It is now cultivated in most subtropical and also in the Northern hemisphere such as Canada and Pacific Northwest regions.

4. World lentil area coverage, production and average yield

The top ten important lentil-growing countries of the world in terms of area coverage are Canada, India, USA,

Turkey, Nepal, Iran, Australia, Syria, Ethiopia and Bangladesh in descending order (FAO, 2010). The total cultivated area in the world as around 4.6 million hectares producing 4.2 million tons of seeds with an average production of 1095 kg/ha (FAO, 2010). Armenia is leading in average yield production (2800 kg/ha) followed by China and Turkey. The average yield in Ethiopia is not greater than 800 kg/ha (FAO, 2010).

5. Adaptation

5.1. Precipitation

Lentils require a minimum of 350 mm rainfall and a maximum of 550 mm; in the higher rainfall areas good drainage is essential; water logging will have a great effect on yields and disease spread. Drought and severe or prolonged hot weather can also cause loss in yields through pod cracking.

Lentil is among the important cool-season food legumes in Ethiopia and is mainly cultivated between 1700 and 2400 meter above sea level where the mean annual rainfall ranges from 700 to 2000 mm (Million Eshete, 1994).

5.2. Temperature

Seeds will germinate at temperatures above freezing but best at the range of 18-21°C; temperatures above 27°C are harmful; optimum temperatures for growth and yields are around 24°C. Lentils are grown as a cool weather or winter crop in the semi-arid tropics, but are not suited to the humid tropics. They are less damaged by drought than by water logging. Small-seeded cultivars are more drought-resistant than large-seeded.

5.3. Soil type

Lentils are grown in sandy loam soils, alluviums, black cotton soils, or in much heavier soils. Lentil does best in soil with pH levels of 6.0 - 8.0 and will not tolerate water-logging, flooding, or soils with high salinity. They may be grown in moderately alkaline or saline soils.

6. Plant characteristics

6.1. Root system

The plants have a slender taproot with fibrous lateral roots. Root patterns range from a many-branched, shallow root system to types that are less branched and more deeply rooted. The taproot and lateral roots at the surface layers of soil have nodules that vary in shape from round to elongated type.

6.2. Leaves

The leaves of the lentil are relatively small compared to those of other large-seeded food legumes. Ten to sixteen leaflets are subtended on the rachis (40-50 mm); upper leaves have simple tendrils while lower leaves are mucronate (Muehlbauer et al., 1985). The leaves are alternate, compound, pinnate, usually ending in a tendril or bristly; leaflets 4-7 pairs, alternate or opposite.

6.3. Inflorescence

Flowers are small, pale blue, purple, white or pink, in axillary and 1 to 4 flowered racemes. There are 1 to 4 flowers borne on a single peduncle and a single plant can produce up to 150 peduncles each being 2.5-5 cm long (Muehlbauer et al., 1985).

7. Growth characterization

Lentil seeds can germinate in the light or the dark and in constant or diurnally fluctuating temperature regimes. However, rates of germination, emergence, and seedling growth are markedly affected by temperature. Optimum values for germination and growth vary with cultivar, age, and size of seeds. Smaller seeded cultivars germinate more rapidly than larger ones at temperatures between 15 °C and 25 °C (Saint-Clair 1972).

The successive stages of canopy formation (stem elongation, leaf initiation, leaf expansion, and branching) have different optimal thermal regimes, which obviously affect the rates at which these processes occur. This may explain a common observation by farmers that lentil seedlings, once emerged, often grow slowly, if at all, for several days or even weeks (for example, successive stages of vegetative development have warmer temperature optima).

Many studies show that lentil yields are remarkably stable over a wide range of population densities. The plants are able to fill available space by initiating lateral branches and, thus, can compensate for poor emergence and thin stands.

8. Crop management

8.1. Seedbed preparation

Fields intended for lentils are usually chisel plowed in the fall to aid water infiltration, control erosion, and maximize the retention of crop residues. Tillage along the contours of hills improves moisture infiltration and prevents excessive runoff and soil erosion (Papendick and Miller 1977). Deep tillage leads to excessive loss of moisture and should be avoided. A well-prepared seedbed which has some crop residues on the surface improves water infiltration and reduces the erosive effects of rainfall. Excessive residues interfere with placing seeds at a uniform depth. Soil temperatures increase quickly when fields are well prepared, resulting in rapid germination,

good emergence, and improved seedling growth.

In case of Ethiopia, one deep plowing in the dry season (March-May) and one to two disking before planting is essential to keep the soil friable and weed free (Geletu et al., 1996). When this crop is grown on flat heavy clay soils, it is important to improve the drainage conditions of the soils. Various experimental findings reported that seedbed preparation method had a profound effect on seed yields of lentils on Vertisols (DZARC 1991, 1994).

8.2. Fertilizers

8.2.1. Nitrogen

Farmers usually do not use nitrogen fertilizers for lentil production. This is due to the ability of lentil to fix atmospheric nitrogen. However, if the available soil nitrogen level is very low (less than 17 kg/ha) at planting, a small amount (20 kg) of starter-nitrogen fertilizer may enhance nodulation and productivity of the crop. Although, high levels of starter nitrogen may appear to help the crop overcome a nitrogen deficiency during early crop growth stages, final seed yield may not increase.

8.2.2. Phosphorus

Lentil has a relatively high requirement for phosphorus to promote the development of extensive root systems and vigorous seedlings. Encouraging vigorous root growth is an important step in promoting good nodule development. Phosphorus also plays an important role in the nitrogen-fixing process. Lentil grown on soils testing low in available phosphorus may respond to phosphate (P_2O_5) fertilizer. As with cereals however, dramatic yield responses are not always achieved with P_2O_5 fertilizers.

In Ethiopia, studies conducted so far indicated lack of response of lentil to N and P fertilizers applications. Despite these facts, the use of 100 kg ha^{-1} DAP was recommended as optimum for the production of lentil in the country (Million, 1994).

8.3. Sowing date

Sowing date is an important agronomic variable in optimizing the seed yield of crops. However, optimum sowing date varies among locations and is dependent upon both the pattern and total amount of rainfall, altitude, soil type, and maturity period of the specific crop cultivar (Getachew, 2001).

According to Million and Geletu (1998), the optimum sowing date for early maturing varieties of lentil is until the mid of July. Similarly for Vertisols, sowing of lentil in July is proved to have a yield advantage over farmers practice (late August to September sowing) provided that the soil is well drained. Geletu (1991) reported more than 87% yield reduction for lentil planted in August compared with those sown in June-July. In general, late June to mid July is the optimum time for planting lentils in the central highlands of Ethiopia (Geletu, 1991; Million, 1994).

8.4. Spacing and seed rate

For sowing lentil in rows, a spacing of 20-25 cm between rows and 2.5 to 5.0 cm between plants for lentils has been recommended to get good yield. However, the seed rate for broadcast method appeared to vary depending on the seed size and growth habit. In general, larger seed size requires higher seed rates than smaller seed size. Thus, a seed rate of 50-65 kg ha^{-1} for small seeded lentil, 65-80 kg ha^{-1} for medium and up to 120 kg ha^{-1} for large seeded lentil cultivars were recommended (DZARC, 2001).

8.5. Method of sowing

Broadcasting is most commonly used method of sowing in Ethiopia. However, recently row planting by drilling method has been also started in some areas.

8.6. Weed control

Lentils compete poorly with weeds for light, water, and nutrients. During early stages of vegetative growth and in cool weather, lentil growth rates are slow and weeds can quickly overgrow the crop. If not adequately controlled, weed infestations can reduce yields by as much as 75 percent. Although the period of crop growth during which competition is most deleterious varies in different locations, competition from weeds is usually serious and requires some form of control in order to produce good seed yields. Wild oats, volunteer cereals, and other annual grasses are common and serious weeds in lentil crops.

In Ethiopia, two times hand weeding within four to eight weeks after the emergence of seedling is essential for weed control in lentil. Spraying with pre-emergence herbicide Terbutrym and prometryin each at 2 $kgha^{-1}$ 2-3 weeks prior to sowing controls annual broad leaved and grass weeds of lentil.

9. Diseases and Insects management

Lentils appear to suffer less from diseases than many other grain legumes. Some of the more serious problems are discussed below.

Root rot/wilt complex

Probably the most important disease problems of lentils worldwide are root rots and wilts caused by *Pythium, Rhizoctonia, Sclerotium*, and *Fusarium* species.

Rust

Rust, caused by *Uromyces viciae-fabae* Pers., is a serious problem in areas with mild temperatures and humid

conditions.

Ascochyta blight

Blight caused by *Ascochyta fabae* , a seed borne disease, causes severe damage in many cool and wet regions.

Botrytis grey mould (*Botrytis cinerea*)

It is another serious disease which attacks the base of the stem and the collar region of young plants, where a soft rot develops and then becomes covered with a fluffy grey mould, infected seed is white and chalky in appearance.

Phoma

Phome is a seed-borne infection that results in black-brown discoloration of the root near where the seed is attached. Blackening may spread up the root and cause lesions at the base of the stem. Black lesions may completely girdle the base of the stem and root where infection is severe.

Seed borne fungi

Reduced seed quality can result from infection by different pathogenic fungi, some of which are also pathogens of chickpeas and peas (Kaiser 1992). The incidence of fungi associated with lentil seeds varies greatly from year to year and is influenced by weather conditions, particularly rainfall. The seed borne pathogens most common in discolored lentil seeds are *Botrytis cinerea* and two *Fusarium* species. In case of excessive rainfall during harvest or when plants are drying in windrows, lentils that remain on or near the moist soil surface may show seed discoloration from colonization and infection of the pods and seeds by pathogenic and saprophytic fungi.

Viruses

Most viruses that infect peas also infect lentils. These include alfalfa mosaic, bean (pea) leaf roll virus (BLRV), bean yellow mosaic, pea enation mosaic virus (PEMV), and pea streak. These viruses are transmitted by pea aphids, generally from infected alfalfa and clover plants. Control of common viruses is best achieved by planting resistant cultivars

Cowpea aphid (*Aphis craccivora*)

Moisture stressed crops are susceptible to aphid infestation, especially when the atmosphere is dry and when warm weather occurs in autumn and spring.

Lucerne flea (*Sminthurus viridis*)

It is a small (2.5 mm), wingless, light green hopping insect. It chews through leaves in layers resulting in "window-pane" like holes.

Bud worm (*Helicoverpa punctigera*)

The caterpillar damages maturing seed in pods during the flowering and podding stage of plant growth.

10. Harvesting

Lentil flowers in 6-7 weeks after planting with early cultivars ready to harvest in 80-110 days, late cultivars reach maturity in 125-135 days. Harvesting is done by cutting to ground level or pulling by hand when they turn golden yellow and left to dry for 5-10 days before being threshed and winnowed. Low moisture is desirable at harvest.

11. Released Varieties of Lentil in Ethiopia

In Ethiopia, many varieties have been released so far and some of these varieties are listed in table below:

Local name	Origin	Source	Year of release (E.C.)
Chalew (NEL 358)	ICARDA	DZARC	1977
EL-142	Ethiopia	DZARC	1972
Ada'a (FLIP 86-14L)	ICARDA	DZARC	1987
Chekol (ENAL-2704)	ICARDA	DZARC	1986
Gudo (FLIP 84-78L)	ICARDA	DZARC	1987
Teshale (FLIP 96-46L)	ICARDA	DZARC	1986
R-186	ICARDA	DZARC	1972
Alemaya (FLIP 89-63L)	ICARDA	DZARC	1989
Alemtena (FLIP 96-49L)	ICARDA	DZARC	1986
Assano (FLIP 88-46L)	ICARDA	SARC	1994

DZARC = Debre-Zeit Agricultural Research Center; SARC = Sinana Agricultural Research Center; ICARDA = International Center for Agricultural Research in the Dry Areas.

Source: Edossa Fikru et al., 2007

Conclusion

Lentil is among the most important cool season food legumes cultivated in rotation with cereal crops in most parts of the country. It is an important legume crop and plays an important role in human, animal feeding and soil improvement. Hence, increasing lentil production has paramount effect in enhancing the economy of the

country and maintaining soil fertility. Poor agronomic practices are among the major constraints limiting the production and productivity of this crop. Proper land preparation, sowing date, seed rate, weeding, and diseases and pests control are important agronomic variables that help to optimize the production and productivity the crop.

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