Short practical guide to dry bean production for Mediterranean drylands with irrigation

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These protocols describe the summary field level management of dry bean production. It is particularly tailored for borlotti and kidney beans to be grown in dry-cold Mediterranean climates such as North Macedonia.

1. Field preparation

Well prepared, uniformly flat field is essential for successful bean establishment. The objective is to have a soil with 2-4 cm loose layer followed by moist layer below at 4-6 cm, where bean seeds are to be placed. Number of tillage operations will depend on the previous crop (i.e., cereals or perennial legumes). For instance, following perennial crops with tap roots that form clumps, plough (fig. 1a) in autumn, tandem disk (disk harrow) (fig. 1b) (one or two operations) in early spring, as well as, power harrow (fig. 1c) and Cambridge roller (fig. 1d) is required. The field at the end should have no clumps and appear flat with no depressions or hills.

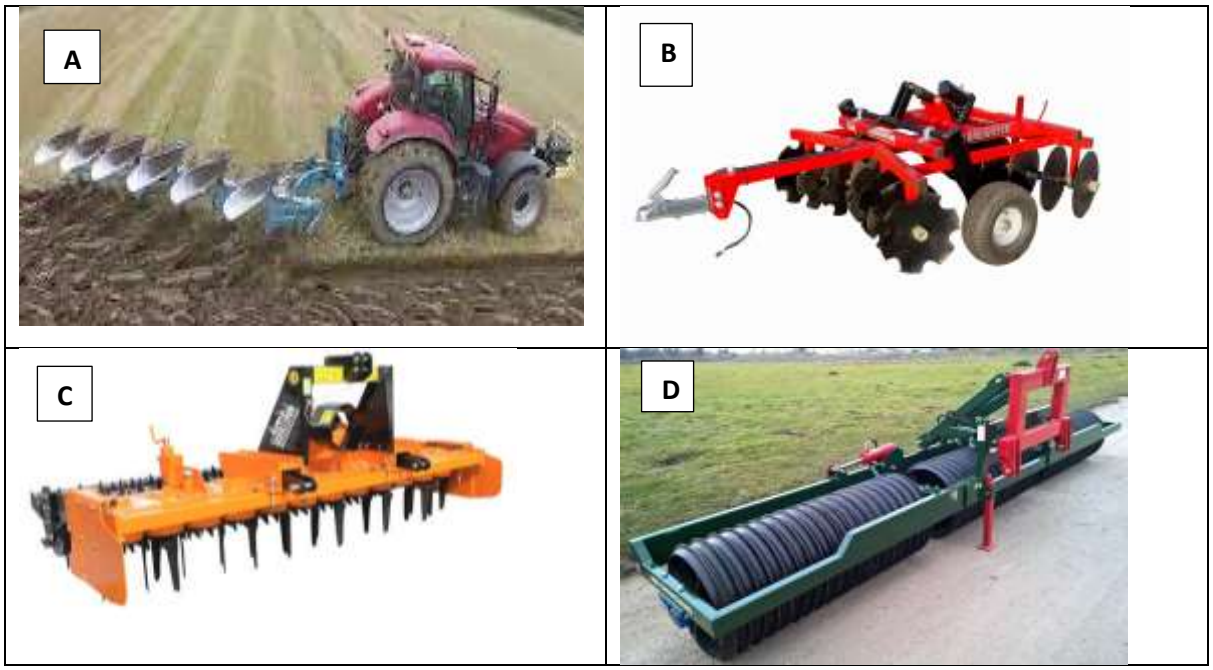

Figure 1: Field preparation equipment a) plough, b) disk harrow, c) power harrow and d) Cambridge roll

Attention should be paid to keep the tillage operations to minimum in order to conserve soil moisture and save fuel. More tillage does not mean better soil preparation. On the contrary, intensive and deep tillage destroys soil structure, evaporates precious soil water and wastes fuel. Field preparation should ideally be finished a few weeks before seeding. If there is a lag time between the time field is prepared until seeding beans, tine harrow can be used to eliminate weed seedlings. Ideally, beans should be seeded after prepared fields receive some rainfall or irrigation that provides moisture to soil layer at 2 cm and below. Beans should be placed in this moist environment for rapid germination and emergence.

2. Seeding date

Selecting a correct seeding date is a challenging task considering the varying weather patterns.

- When seeding the soil temperature should be > 13° C
- There must be sufficient rainfall or irrigation during flowering
- Flowering in hot and dry spells will kill the flowers

Based on the) experience in 2019 and rough analysis of last 20 years' data indicate that most of the heat waves occur around July 5-20, as well as, in the second and third week of August. Beans usually reach flowering in 6-8 weeks depending on variety and the weather conditions. Based on this, it is recommended that beans are to be seeded before May 1st, in order to avoid the heat wave in July. Alternatively, beans could be seeded late May but under such circumstances, timely availability of irrigation becomes critical.

3. Seeder calibration and seeding

Dry beans are very susceptible to physical damage and may lose viability if chipped or broken. Seeder fan speeds should be adjusted to ensure no damage for the seeds. Seeder calibration entails adjusting the seeding rate and depth at a given speed. Attention must be paid to ensure accurate seed placement depth and distance. A mistake made during seeding operations will last the whole season and may significantly reduce yield potential. Seeding beans on a straight line (driving tractor on a straight line during seeding) is very important because straight lines will provide easier and more effective weed control later in the season. It will also prevent unwanted damages to bean crop during the tillage operations.

The ideal seeding depth range for beans is 3-6 cm. Exact seeding depth will depend on the soil moisture levels and expected rains. Beans should be seeded in a period, when no rain is expected for at least a week, in order to avoid surface crusts. Sandy soils are particularly susceptible for surface crusting (Figure 2a), which prevents bean emergence. Unlike other crops, which only have to push their shoots through the soil, beans have to push their large cotyledons (Figure 2b) through soil. This is especially difficult for the large varieties such as borlotti.

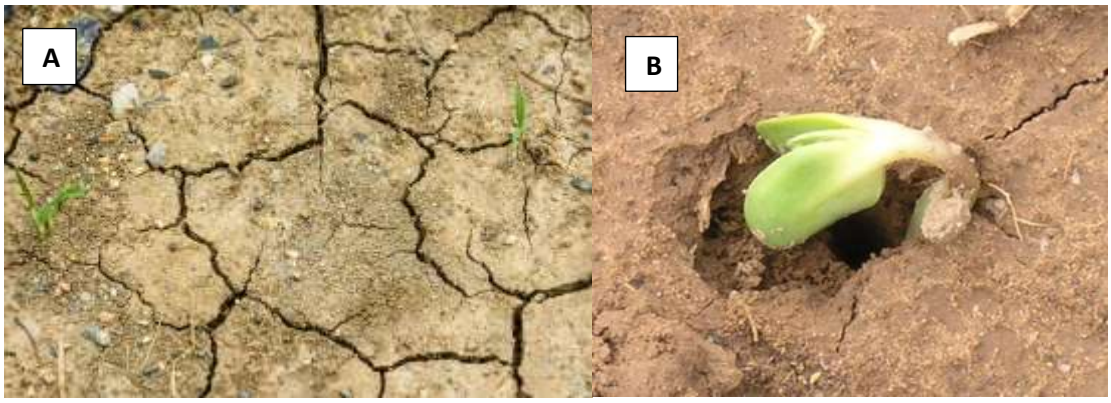

Figure 2: a) Soil crust forming after rains, b) bean emergence through soil

Ideal seeding rate for beans under organic conditions ranges from 16 – 25 seeds per m². Kilogram of seed to be seeded per hectare will depend on the 1000 seed weight. Borlotti seeds are very large and can weigh 400 – 700 g per 1000 seeds.

For Macedonian conditions the seed rate can be calculated as follows:

Row width	60 cm
Distance between seeds in a row	8 cm
1000 seed weight	550 g
% emergence	90% (assumption)
Target population	20 plants/m²
Seeding rate*	= (20 x 550)/90
Seeding rate	**122 kg/ha**

*Seeding rate = (Target population x 1000 seed weight) / %emergence

Beans, being poor competitors with weeds, need to be seeded at high seeding rates especially under organic management. To achieve high seeding rates, row distance can simply be reduced from traditional 70 cm to 50-60 cm. This ensures full canopy closure by bean plants and prevents sun rays to penetrate into rows where weed seeds are ready to germinate with available warmth and light.

In 2019 the farmers in Mustafino controlled weeds very well during the vegetative period of the beans before flowering (see pics) using an imported Turkish in-row cultivators (finger-weeder). During this period weeds germinate and grow slower than in the summer period. However, with irrigation and heat after June, new weed seeds are continuously germinated and grow fast. During this intense period, weeds must be controlled using hand labour if necessary. Labourers need very close supervision for proper execution of their duties. Therefore, the bean area to be seeded should be estimated based on the availability of managerial and labour workforce (capacity to manage in both human resources and financial terms).

Figure 1: In-row cultivation of beans during vegetative stages. Pictures taken on 22.06.2019

The minimum soil temperature for seeding beans is 13-14 °C. Soil temperatures should be monitored and before seeding using a simple thermometer. If weather forecast is calling for cooler or rainy days immediately after planned seeding date, the seeding should be postponed. There should be no danger of frost after seeding. Beans thrive at temperatures around 18 – 25 °C but may suffer temperatures above 30 °C during flowering stage. When planted in warmer soil temperatures (i.e., 15-16 °C) emergence will be much faster.

Best pH range for beans is 6 to 8. Below pH of 5.5 lime should be applied. Beans ability to fix N is reduced above pH of 8.

4. Weed management

Beans are very poor competitors with weeds. Especially at early stages (up to 40 days after sowing) field needs to be kept free of weed seedlings. Passing with tine harrow (Figure 4) before (depending on the weed seedlings density) and few days after seeding beans will control most of the early weeds. If bean seeds have already started to emerge, harrowing cannot be done. Clean field at the early stages will enable beans to use available resources most effectively and increase the yield potential. Borlotti beans are essentially horticultural crops and requires close attention and care for good yields. Good care means frequent visits to fields, timely weeding and irrigation, as well as disease and weed control.

FiBL has developed a short description on "false seedbed" concept: https://shop.fibl.org/CHen/mwdownloads/download/link/id/1058/?ref=1

Figure 4: A tine harrow

After bean seedlings reach 2 leaf stage, (if there is a weed pressure) a tine cultivator (preferable with protective disks) can be used. At 6 leaf stage, tine cultivator and finger weeders can be useful (Figure 5).

Figure 5: Goosefoot cultivator with finger weeders

5. Nutrient management

The most important two nutrients for bean production are nitrogen (N) and phosphorus (P). Beans can fix N from air through association with *Rhizobium* bacteria forming nodules (Figure 6). All beans must be inoculated with appropriate rhizobium inoculum on the day of the seeding.

However, amount of N fixed by beans are rarely enough for bean production. If an expected yield is around 1.5 -2 t/ha, around (N content of 4 %), beans will need 60 – 80 kg/ha of N. Assuming beans can fix around 30% of their own N though association with rhizobium, 40 to 60 kg/ha of N will be needed.

Pelleted chicken manure is a good choice of N source because it does not contain weed seeds and can be placed near the bean seeds for optimum efficiency. The amount of pelleted chicken manure to be applied will depend on the soil test results on soil nitrate (NO^-_3) levels. Depending on the product, pelleted chicken manure may contain around 4% N. As such 1 t/ha of pelleted chicken manure contains around 40 kg/ha of N.

Figure 6: Nodules on a bean crop.

Beans need around 20 kg/ha of P to achieve 1.5 -2 t/ha of bean yield. Pelleted chicken manure contains high amount of P and rates adjusted for N fertility will be sufficient for P requirements.

6. Irrigation

Before seeding, seedbed should be checked and ensure that there is enough moisture for establishment and early development. If there is not enough moisture between 3 and 10 cm of depth, a light irrigation of 15 mm (15 L/m^2) can be applied. It is not advisable to irrigate after seeding until beans emerge. Beans require around 300 – 400 mm of water per growing season.

Unlike cereal crops, beans are shallow rooted crops reaching maximum of 60 cm below soil during flowering. Before flowering (i.e., vegetative stage) bean crop uses water up to 30 cm soil depth. Therefore, light and frequent irrigation is preferable to large volume of water in order not to waste water resources and leach precious nutrients. Up to flowering stage, weekly irrigations of 20 mm will suffice to meet the crop demand.

Closer to and during flowering larger volumes of water will be needed (40 mm). It should be made sure that soil profile at 60 cm depth is kept near field capacity. Field capacity refers to content of water that a particular soil can hold. For instance, loamy soils in Macedonia can hold around 30 L of water per m^3 of soil. Beans are most sensitive to water stress during flowering and pod setting stages. Beans can use 6-7 mm of water per day, before and during flowering and pot setting. This means bean crops can use around 40 mm of water /m^2 (6mm x 7 days = 42 mm) per week.

Excess irrigation may lead to root rot and Sclerotinia, as well as leached nutrients. Irrigation can be stopped when 20-30% of the bean pods started to change colour and turn yellow.

Sufficient quantity and timely availability of irrigation from government run channels or wells is a challenge for bean producers. In Mustafino in 2019, for instance, first irrigation water was available only after May 20, which would have been late if there were no rains. Additionally, during the heat wave in early July, there was not sufficient water in the channels.

Water is usually pumped from channels using diesel engines, which are expensive to operate and maintain. Another problem is the pipes used for irrigation. Limited length of the pipes and limited capacity of diesel engines results in limited area coverage. This means that pipes need to be constantly moved across fields all day long to ensure full coverage. Consequently, irrigation must be done during the day, where sun rays are strong. When applied during the heat of the day, moisture increases the disease pressure and wastes the precious water through evaporation, hence further increasing the water stress of the plants. Ideally irrigation should be applied at dawn or in the evening. Another implication of this system is the labour required to change the location of pipes.

7. Disease management

As a preventative measure to reduce the incidence of *Pseudonomas* and *Xanthomonas* on beans, copper based, organically approved pesticides should be used. Application rate ranges from 800 to 1000 g of pure copper per hectare. Two applications during vegetative stages will suffice. The product should contain at least 20-30 % copper as an active ingredient.