Effect of Microbial Inoculants and Mineral Elements on Drought Resistance and Yield of Field Bean

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Abstract

Three factors that can help to reduce the adverse effects of drought on crop plants are: surface mulches to prevent evaporation of soil moisture; a well-developed root system to maximize the absorption of water and nutrients; and, optimum and balanced nutrition which allows plants to use water more efficiently. A field study was conducted to determine the effect of two-microbial inoculants and different sources of mineral elements on drought resistance and yield of field bean. Treatments included: microbial inoculants applied to the seed and leaves; seed pelleted with quicklime and inoculants; and, mineral sources applied to the seed and soil. Results showed that neither the mineral sources nor the microbial inoculants alone could improve drought resistance of the crop plants; however, when used together there was a definite improvement for certain combinations. Widespread adoption of these formulations by farmers will depend on their cost-effectiveness.

Introduction

Optimally-nourished crop plants often have a lower water requirement than inadequately nourished plants because they use water more efficiently (Boguslawski, 1958). Optimum nutrition depends on a well-developed root system which is enhanced by a well-aggregated porous soil; and, a proper level and balance of available nutrients. Surface mulches are an important part of the system since they conserve soil moisture by limiting evaporative losses.

According to some research findings, micro nutrients (i.e., trace elements) alone appear to have little effect on drought resistance or drought tolerance. The reason for this may be that many crops have low seed reserves of micro nutrients (Bakurdzhieva, 1970). Subsequently, it was shown that seed enrichment with micro nutrients can increase their absorption and use by plants, resulting in increased growth and yield (Primavesi, 1967; Primavesi and Primavesi, 1970; Primavesi et al., 1971; Primavesi, 1980, 1994).

The uptake of certain nutrients by plants may depend on local agroclimatic conditions. For example, it has been reported that on dry, sunny days plants need and absorb more nitrogen, potassium and calcium (Haas, 1966), and more zinc or boron (Malavolta et al., 1962; Wing and Mackenzie, 1972), than on cloudy, rainy days.

The purpose of this study was to determine the effect of microbial inoculants and mineral elements, and combinations thereof, on drought resistance and yield of field bean.

Methods and Materials

The experimental site consisted of a red-yellow podzolic soil (sandy phase) which was well-aggregated, porous and relatively uncompacted to a depth of 25 cm as determined by a soil penetrometer.

Composition of the Microbial Inoculants

Effective Microorganisms (EM):

EM consists mainly of lactic acid bacteria, photosynthetic bacteria, yeasts and actinomycetes, along with other genera and species of beneficial microorganisms. The inoculant is formulated by anaerobic fermentation with molasses as a carbon and energy source. It is diluted with water prior to use.

RG or Supermagro:

RG consists of fresh farmyard manure (FYM), fresh milk, and a nutrient mixture (Ca, Mg, Fe, Cu, Zn, B, Mo, Co) diluted with water and formulated by aerobic fermentation for approximately three weeks prior to use. The addition of fresh milk allows the build-up of lactic acid bacteria.

Composition of the Nutrient Sources

Skrill:

This is a commercially-available product derived from evaporated sea water and consists mainly of Na, Cl, Ca, Mg, K and other mineral elements in smaller amounts.

Fosmag:

This is a commercially-available product often used as a fertilizer supplement applied mainly to soil (P 14%, Ca 13%, K 10%, S 8%, Mg 3%, Zn 0.6%).

Field bean (var. Carioquinha) was planted in the dry season during which rainfall occurred only once, 25 days after emergence. Five rows of beans were planted in 2.4 x 2.0 m plots with only the three inner rows, consisting of 60 bean plants, harvested for yield data.

Treatments Applied

Soil Treatments:

- Fosmag applied at 300 kg ha^{-1}.
- Rock powder (MB-4) applied at 800 kg ha^{-1}.

Seed Treatments:

- EM (concentrated), spray-applied.
- Skrill (6%), spray-applied.
- Quicklime (CaO) applied as seed coating.
- Co-Fe-Mo (cobalt, iron, molybdenum) salts dusted on seed.
- RG (0.5%), spray-applied.
- FTE (fritted trace elements), dusted on seed.

Leaf (Foliar) Treatments:

- EM (0.2%), spray-applied.
- RG (0.5%), spray-applied.
- Skrill (1.5%), spray-applied.
- Water (control), spray-applied.

The plots receiving soil and seed treatments were randomized within blocks according to the foliar treatments which were applied at 8, 18 and 28 days after seedling emergence.

Results

Emergence and early growth of bean plants were satisfactory despite the lack of adequate soil moisture. Nevertheless, the adverse effects of drought on plant growth and development became progressively more pronounced. For example, when plants reached the flowering stage, some began to shed their flowers, wilt permanently and die. Consequently, after three months only 13 to 68 percent of the plants were still alive depending on the treatment; and, only 43 percent of the plants had pods some of which were not filled because of severe stress.

Table 1. Effect of Different Combinations of Microbial Inoculants and Nutrient Sources Applied to Seed, Soil and Leaves on Yield of Field Bean Grown under Drought Conditions.

Foliar Treatments	Seed Treatments (g plot^{-1})						Soil Treatments (g plot^{-1})	
	EM	**Skrill**	**CaO**	**Co-Fe-Mo**	**RG**	**FTE**	**Fosmag**	**MB-4**
EM	67	161	422	206	206	99	0	0
RG	82	181	321	41	24	0	175	259
Skrill	44	44	182	123	396	86	41	20
Control	41	144	143	143	257	0	257	61

Effect of various combinations of microbial inoculants and nutrient sources applied to seed, soil and leaves on bean yields under drought conditions is shown in Table 1. In some severely stressed plots there was essentially no recordable yields. However, it is indeed interesting that three particular treatment combinations produced bean yields higher than all others. Accordingly, these were:

1. EM (leaf treatment) + CaO (seed treatment)
2. RG (seed treatment) + Skrill (leaf treatment)
3. RG (leaf treatment) + CaO (seed treatment)

The yields of these treatment combinations were 422, 396 and 321 g $plot^{-1}$ which are equivalent to 1318, 1237 and 1003 kg ha^{-1}, respectively.

Conclusions

Neither of the microbial inoculants EM and RG applied alone to the seed and leaves provided very much drought resistance to the bean plants. However, when these two inoculants were applied to leaves in combination with quicklime (CaO) coated seed, drought resistance was enhanced as evidenced by the higher yields. Seed treatment with RG and leaf treatment with Skrill also appeared to convey considerable drought resistance to the plants.

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