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Productivity and Water Suppression in Different Beans (*Phaseolus vulgaris* L.) Phenological Stages

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Abstract. *Common Bean (Phaseolus vulgaris L.) is widespread in the social and economic scene in Brazil, as well it is Brazilian population main dish, and it also helps small and medium farmers' income. The objective of this study was to compare the productivity performance of common bean Carioca - IAC Alvorada with irrigation suppression in each of the five phenological phases. The experiment was conducted in plots in a greenhouse at College of Agronomical Sciences, São Paulo State University (UNESP), Botucatu – SP. The hypothesis is that if the water supply is suppressed in one of the five development stages of irrigated common beans, the yield reduction would be at least 20%. The treatments consisted of suppression irrigation in one of the five development stages (stage V1 to V3, stage V4 to early flowering, flowering stage, pod formation stage and pod filling stage) compared with the irrigation at all stages and suppression of irrigation at all stages, with seven treatments and four replications. The treatments most affected by water suppression were those which suffered suppression of irrigation during the vegetative phase and flowering stage. Treatments with water suppression in all stages, and suppression during the phases (stage V1 to V3, stage V4 to early flowering, flowering stage, pod formation stage and pod filling stage) showed yield reduction of approximately 95%, 55.1%, 49.5%, 63,1%, 30.2% and 35.6%, respectively, when compared to treatment with irrigation all stages. All treatments considered confirmed the hypothesis.*

Keywords. *Phaseolus vulgaris* L., Phenological Phases, Irrigation Suppression, Production

Introduction

Common Bean (Phaseolus vulgaris L.) is widespread in the social and economic scene in Brazil, as well it is Brazilian population main dish, and it also helps small and medium farmers' income.

In many places of the world common bean production is carried out under drought stress conditions, due to insufficient water supply by rainfall and/or irrigation (Machado Neto and Durães, 2006; Zlatev and Stoyanov, 2005).

Bean water stress results in accelerated maturity and grain yield reduction (Nielsen and Nelson, 1998; Molina et al., 2001; Emam, 1985).

Almost 60% of common bean production in the developing world occurs under conditions of significant drought stress (Graham and Ranalli, 1997). This is probably the reason why the average global yield of beans remains low (<900 kg ha^{-1}) (Singh, 2001). Emam et al. (2010) reported that bean seed yield reduction due to drought stress are attributed to adverse effects of the stress on individual yield components (number of pods per plant, number of seeds per pod, seed weight and harvest index).

Drought stress is one of the limiting factors for crop growth and yield which reduces dry matter production, yield and yield components through decreasing leaf area and accelerating leaf senescence (Emam and Seghatoleslami, 2005). It has considerable impact on common bean growth and seed yield (Emam, 1985; Shenkut and Brick, 2003, Frahm et al., 2004).

Some management practices, like irrigation, can contribute to the increase of grain yield under water stress conditions, thus the development of tolerant cultivars becomes an efficient and economical production strategy (Zlatev and Stoyanov, 2005; Molina et al., 2001).

The objective of this study was to compare the productivity performance of common bean Carioca - IAC Alvorada with irrigation suppression in each of the five phenological phases. The hypothesis is that if the water supply is suppressed in one of the five development stages of irrigated common beans, the yield reduction would be at least 20%.

Material and Methods

The experiment was conducted in plots in a greenhouse at Department of Rural Engineering, College of Agronomical Sciences, São Paulo State University (UNESP), Botucatu – São Paulo - Brazil. The culture used was the common bean (*Phaseolus vulgaris* L.), Carioca Group, IAC – Alvorada, with cycle of approximately 90 days.

The treatments consisted of irrigation suppression in one of the five development stages (irrigation suppression in stage V1 to V3 (VI) – T2, suppression from stage V4 to early flowering (VII) – T3, suppression during flowering stage (Fl) – T4, suppression during pod formation stage (Po) – T5, and suppression during pod filling stage (Pf) – T6) compared with the irrigation at all stages (T7) and suppression of irrigation at all stages (T1).

Each plot consisted of three plants and the statistical design was randomized blocks with seven treatments (Table 1) and four replications in vase of 9 L.

Irrigation was conducted to increase the soil water content to the condition equivalent to soil field capacity. The plots were irrigated when the critical stress reached between 30 to 35 kPa. The tensiometer was used to detect this range. The irrigation suppression allowing and irrigation depth equivalent to 25% of the bean water requirement.

Data were analyzed using SAS statistical program, subjected to analysis of variance and “t” test at 5% probability.

Table1. Treatments with irrigation at all phases, suppression of irrigation in all phenological phases and suppression of irrigation in one of the five development stages.

	VI	VII	Fo	Po	Pf
T1					
T2					
T3					
T4					
T5					
T6					
T7					

VI – Phenological stages V1 to V3; VII – Stages V4 to early flowering; Fl – Flowering stage; Po – Pod formation stage; Pf – Pod filling stage

Results and Discussion

The Figure 1 is shown the productivity per plot with the different treatments.

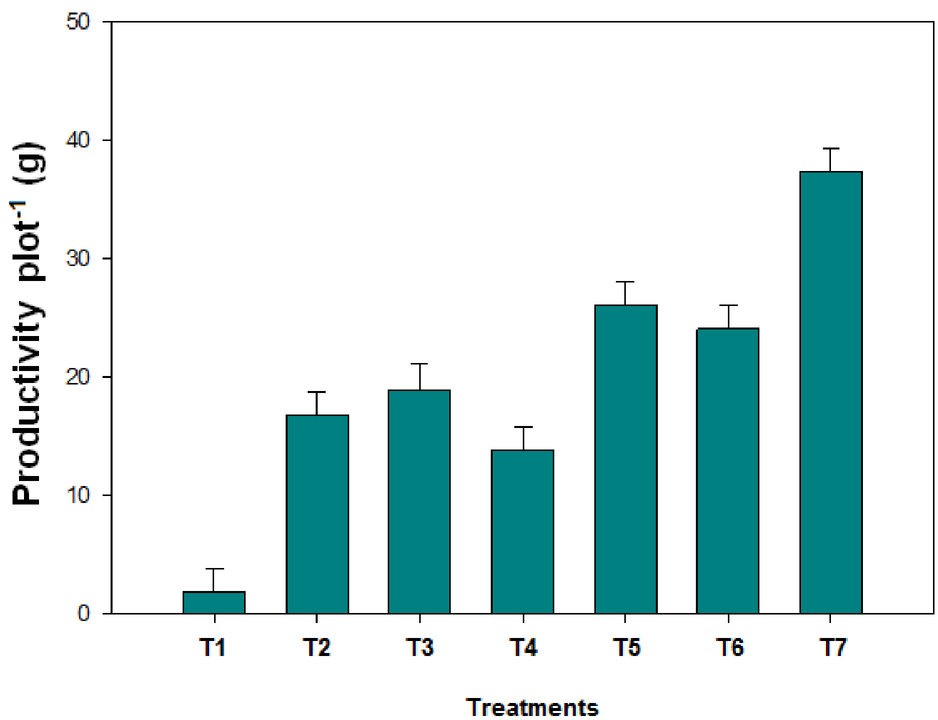

Figure 1. Productivity per plot (g) in suppression of irrigation in one of the five development stages, compared with the irrigation at all stages and suppression of irrigation at all stages.

The productivity per plot (g) was 37.4 g for the treatment with irrigation at all stages (T7) and it decreased to 1.8 g for the treatment with suppression of irrigation at all stages (T1), showing a productivity reduction of approximately 95%. In addition, the treatment with irrigation at all stages differed from all other treatments. Molina et al. (2001) reported that water stress reduced grain yield of common bean cultivars, by approximately, 50%, however, the IPR88 Uirapuru cultivar, from the black commercial group, and the LP 97-13 and LP 97-4 lines from the carioca commercial group, stood out as “drought tolerant” and showed high yield potential.

Treatment with water suppression during flowering stage (T4) was the most affected, but did not differ from treatments with irrigation suppression in stage V1 to V3 (T2) and with water suppression in stage V4 to early flowering (T3). When compared to treatment with irrigation at all stages (T7), the productivity of treatment with irrigation suppression during the flowering stage (T4) decreased approximately 63.1%. Periods of water stress during the reproductive phase of the common bean has been associated with a significant reduction in grain yield (Eman and Seghatoleslami, 2005; Eman, 1985; Miller and Burke, 1983). Decrease in grain yield has been resulted from a lower percentage of pod production when drought occurred during flowering (Eman, 1985). Stoker (1974) suggested that reduction in yield in dry beans under water stress was caused mainly by abscission of flowers and young pods.

The treatments most affected by water suppression were those which suffered suppression of irrigation during the vegetative phase (suppression during the stage V1 to V3 (T2) and suppression during the V4 to early flowering (T3)) and suppression of irrigation during flowering stage (T4). Treatments with water suppression in V1 to V3 (T2) and suppression of irrigation in V4 to early flowering stage (T3) did not differ and had a drop in productivity of 55.1% and 49.5% respectively, when compared with irrigation at all phenological stages (T7). During the bean development stage (vegetative stage), the water deficit had an indirect effect on productivity by reducing leaf area. Gunton and Everson (1980) and Emam (1985) reported dry beans leaf area was reduced when the plants were exposed to drought stress during vegetative growth stage. Markhart (1985) also found significant reductions in the leaf area under drought conditions at 23 days after planting for two bean species (*P. vulgaris* and *P. acutifolius*). Indeed, loss of leaf area, which could be resulted from reduced size of younger leaves and inhibition of the expansion of developing foliage, is also considered as an adaptation mechanism to soil moisture deficit (Emam, 1985; Acosta-Gallegos and White, 1995).

Treatments with water suppression during pod formation (T5) and with suppression of irrigation during pod filling (T6) were the less affected by water deficit and they showed yield reduction of approximately 30.2% and 35.6%, respectively, when compared to treatment with irrigation all stages (T7). These two treatments (suppression of irrigation in pod formation and water suppression in pod filling) did not differ. Water stress during the flowering and pod filling periods reduced seed yield and weight, and accelerated maturity of dry bean (Zlatev and Stoyanov, 2005; Szilagyi, 2003). Decrease in grain yield has been resulted from embryos abortion, when it occurred in the pod formation stage (Robins and Domingo, 1956).

Conclusion

All treatments considered confirmed the hypothesis that the productivity decreased at least 20% when irrigation suppression occurred in one of the five development stages of irrigated bean.

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