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# Effect of Row and Plant Spacings on Weed Competition with Pinto Beans (*Phaseolus vulgaris* L.)

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## ABSTRACT

**Field experiment was conducted at the agricultural experiment station of Shiraz University at Kushkak in 1996 to quantify the competitive ability of pinto beans (*Phaselus vulgaris* L. var. Daneshjou) with a naturally occurring population of weeds. An attempt was made to increase the competitive ability of the plants by altering row and plant spacings. An uncontrolled population of weeds reduced pinto bean yields by 75%. The ability of plants to reduce weed dry weight was further enhanced in medium and narrow rows compared to wide rows. Row and plant spacing combinations which maximized leaf area index when grown under weedy conditions also had significantly less weed dry weight. However, row and plant spacings did not reduce weed density. A significant negative correlation was observed between weed dry weight with leaf area index and final yield of pinto bean. For each kg ha$^{-1}$ increase in weed dry weight, the corresponding pinto bean yield loss averaged 260 g ha$^{-1}$. Season-long weed competition significantly reduced total number of pods per plant, number of seed per plant, and 100-seed weight.**

**Keywords**: Pinto beans, Weed competition, Weed interference.

## INTRODUCTION

Chemical weed control has been a dominant compenent of weed management in bean production over the past 30 years. In recent years, consumer awareness of food production practices has increased. This increased awareness has clearly included fears regarding the potential misuse of pesticides. These issues have promoted interest in alternative approaches to weed management. A key component of these approaches is the enhancement of crop competitiveness against weeds (18). Manipulating agronomic factors such as row and plant spacings may provide a nonchemical means of reducing the impact of weed interference on crop yields.

Several studies have been performed on the influence of spatial arrangement, particularly row width, on weed competition with beans. Experiments with white beans in Ontario, Canada, showed that planting in narrow row spacings of 25 to 50 cm may provide better competition with weeds due to leaf canopy shading on the soil surface [14, 19]. Malik *et al* [12] reported that the ability of bean cultivars to reduce weed biomass was further enhanced in medium and narrow rows compared to traditional wide rows. Average reductions in total weed biomass under medium and narrow rows compared to traditional wide rows was 18%, but increasing seeding density in either medium or narrow row spacing did not reduce weed biomass. Teasdale and Frank [19] reported higher seed yield and improved weed suppression when snap beans were grown in 46-cm rows rather than 91-cm rows. Additionally, when weeds were controlled for the first half of the season, weed supperssion was 82% higher in 15-to 36-cm rows than in 91-cm rows. Similar findings have been reported for other crops [10, 13, 21].

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In crop production studies in Ontario, the yield of white beans under weed-free conditions did not respond economically to populations of more than 25000 plants per ha in traditional wide rows [12]. This response was influenced by cultivar selection. Grafton *et al*. [8] observed the potential for greater seed yield increase with higher populations in determinate cultivars of dry beans. In contrast, Nienhuis and Singh [15] demonstrated that indeterminate cultivars of dry beans showed a yield plateau over a wide range of densities. Malik *et al* [12] concluded that white beans planted at a high seeding density under season-long weed interference yielded 16% more than white beans planted at the normal density in medium (46 cm) row widths. However, density did not affect yields of white beans harvested from weed-free plots. Although bean plants have some ability to compensate for lower plant stands (6), it was observed that fields with lower plant stands suffered most from the presence of weeds [2, 7]. The objective of this study was to investigate the effects of row and plant spacings on weed competition in pinto beans.

## MATERIALS AND METHODS

### General

Field experiment was conducted in 1996 at the agricultural experiment station of Shiraz University at Kushkak, on a clay loam soil (Xerochrept calcixerollic) with a pH of 7.3 and organic matter of 1.6%. The experimental area was fall moldboard plowed. In the spring, seedbed preparation consisted of two passes with a tandom disk. Plots (7 × 3 m) were established in an area heavily infested with weeds. Major weed species present included field bindweed (*Convolvulus arvensis* L.) 54%, *Rapistrum rugosum* L. 41%, purslane (*Portulaca oleracea* L.) 2%, and other weed species 3% out of a total weed population.

Pinto bean plants were planted on May 20, 1996 in nine densities (patterns) consisting of combinations of three row spacings (45, 60, and 75-cm) and three plant spacings (5, 10, and 15-cm). Bean plants were evaluated at various physiological stages of growth as described by Nuland [16]. These stages were V-3 (second trifoliate), R-1 (first flowering), R-3 (50% flowering), R-7 (late pod filling), and R-9 (maturity).

Pinto beans were hand harvested from an undisturbed central area 4 m by 1.5 m within each plot. After harvesting, plants were oven dried for 48 h at 70 C and then cleaned. An adjustment was made to the final pinto bean yield to account for a moisture content of 14%.

### Weeds

Weed observations were recorded from two randomly selected 50-by 50-cm quadrats within each plot at four physiological stages (V-3, R-1, R-7, and R-9) of pinto bean growth. Aboveground weed biomass was mechanically clipped at the soil surface and oven dried for 48h at 70 C.

### Crop Parameters

The plant leaf area index (LAI) was recorded from five randomly selected pinto bean plants from each plot at four physiological stages (V-3, R-1, R-3, and R-7) of growth. The number of pods per plant and number of seeds per pod were recorded at R-9. The 100-seed weight was recorded from two random samples from the final seed lot. Additionally, plant height, number of branches per plant, and number of main stem nodes were also recorded for five randomly selected pinto bean plants from each plot at R-9.

### Statistics

The experimental design was a split-split plot with four replications. Row spacing was the main plot and plant spacing was the sub-plot. Half of the intercepting block of row and plant spacings was season-long weedy and the other half was season-long weed-free by handweeding.

All data were subjected to the analysis of variance (ANOVA) procedures. After partitioning the data for weedy and weed-free treatments, it was observed that variances of weedy and weed-free treatments were heterogeneous. Therefore, all inferences in this study were based on sub-sub plot separation. Means were separated at the 5% level of significance using Duncan's multiple range test for row and plant spacing main effect and row×plant spacing interaction.

## RESULTS AND DISCUSSION

### Weeds

Planting pinto bean in rows narrower than 75-cm significantly reduced total weed dry weight by the first flowering (Table 1). Other studies [8, 12, 13, 14] showed no effect of reducing soybean or common bean row width on weed biomass accumulation until the initiation of the reproductive growth stages of the crop. Weed dry weight under wide and medium rows at R-1, and under medium and narrow rows at R-7 was not changed. Average reductions in total weed dry weight under medium and narrow rows compared to wide rows was 13%. Reductions in weed biomass due to narrowing soybean or white bean row spacing have been reported previously [11, 12, 20, 21]. Decreasing plant spacing within rows significantly reduced weed dry weight and the interaction of row and plant spacings with weed dry weight was significant. However, in most cases at the reproductive stage, decreasing plant spacing from 15-to 10-cm did not reduce weed dry weight, but when plant spacings were decreased to 5-cm (high density) a significant reduction in weed dry weight occurred at any given reproductive growth stage of pinto bean. There was no effect on total weed density m$^{-2}$ due to row and plant spacings of pinto beans at any growth stage (data not shown). Malik *et al.* [12] also observed that weed density was not affected by row spacing or seeding density

**Table 1.** Total dry weight as affected by row plant spacings.

| Treatment | | Weed dry weight (gm$^{-2}$) | | | |
|---|---|---|---|---|---|
| Row spacing (cm) | Plant spacing (cm) | V-3 | R-1 | R-7 | R-9 |
| 45 | 5 | 71 a[a] | 168 e | 349 e | 404 f |
| | 10 | 73 a | 218 bc | 430 c | 480 de |
| | 15 | 72 a | 223 ab | 452 bc | 507 cd |
| 60 | 5 | 73 a | 192 d | 360 e | 424 f |
| | 10 | 71 a | 199 cd | 440 bc | 499 cd |
| | 15 | 74 a | 244 a | 466 b | 529 bc |
| 75 | 5 | 72 a | 197 cd | 369 d | 475 de |
| | 10 | 74 a | 245 a | 470 ab | 551 b |
| | 15 | 75 a | 239 ab | 500 a | 602 a |
| | 5 | 72 a | 182 c | 368 b | 431 b |
| | 10 | 72.7 a | 221 b | 447 a | 510 a |
| | 15 | 73.3 a | 235 a | 473 a | 540 a |
| 45 | | 72 a | 200 b | 411 b | 464 b |
| 60 | | 72.7 a | 212 ab | 422 b | 484 b |
| 75 | | 73.3 a | 227 a | 455 a | 543 a |

[a] Means within the same column followed by the same letter are not significantly different according to Duncan′s multiple range test (P=0.05).

**Table 2**. Leaf area index of pinto bean as affected by row and plant spacings.

| Treatment | | LAI | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Weed-free | | | | Weedy | | | |
| Row spacing (cm) | Plant spacing (cm) | V-3 | R-1 | R-3 | R-7 | V-3 | R-1 | R-3 | R-7 |
| 45 | 5 | 0.73 a[a] | 2.88 a | 3.32 a | 5.9 a | 0.70 a | 2.16 a | 2.40 a | 3.35 a |
| | 10 | 0.41 c | 1.53 c | 1.97 cd | 3.16 c | 0.38 c | 1.14 c | 1.41 cd | 1.75 cd |
| | 15 | 0.26 de | 1.00 de | 1.44 def | 2.49 d | 0.22 de | 0.74 d | 1.02 cde | 1.25 de |
| 60 | 5 | 0.55 b | 2.29 b | 2.73 b | 4.14 b | 0.52 b | 1.79 b | 2.01 ab | 2.45 b |
| | 10 | 0.27 d | 1.15 d | 1.83 ced | 2.50 d | 0.26 d | 0.86 d | 1.30 cde | 1.33 de |
| | 15 | 0.18 ef | 0.80 ef | 1.24 ef | 1.92 d | 0.17 e | 0.60 de | 0.88 de | 0.95 e |
| 75 | 5 | 0.44 c | 1.78 c | 2.22 bc | 3.71 c | 0.44 c | 1.34 c | 1.63 bc | 2.04 bc |
| | 10 | 0.24 de | 0.91 de | 1.35 ef | 1.96 d | 0.20 de | 0.68 de | 0.97 de | 1.05 e |
| | 15 | 0.15 f | 0.58 f | 1.02 f | 1.51 de | 0.15 e | 0.45 e | 0.73 e | 0.81 e |
| | 5 | 0.57 a | 2.32 a | 2.76 a | 4.58 a | 0.55 a | 1.75 a | 2.01 a | 2.61 a |
| | 10 | 0.31 b | 1.20 b | 1.72 b | 2.54 b | 0.28 b | 0.89 b | 1.23 b | 1.38 b |
| | 15 | 0.20 c | 0.79 c | 1.23 c | 1.97 c | 0.18 c | 0.60 b | 0.88 b | 1.00 b |
| 45 | | 0.47 a | 1.80 a | 2.24 a | 3.85 a | 0.43 a | 1.35 a | 1.61 a | 2.12 a |
| 60 | | 0.33 b | 1.41 b | 1.93 a | 2.85 b | 0.32 b | 1.07 ab | 1.40 ab | 1.58 b |
| 75 | | 0.28 c | 1.09 c | 1.53 b | 2.39 c | 0.26 c | 0.82 b | 1.11 a | 1.30 b |

[a] Means within the same column followed by the same letter are not significantly different according to Duncan′s multiple range test (P=0.05).

in white bean cultivars.

## Crop Parameters

The LAI of pinto beans was not affected by the presence of weeds up to the second trifoliate stage of crop growth (Table 2). Malik *et al* [12] also observed that the LAI of white bean was not affected by the presence of weeds up to the second trifoliate stage of crop growth. By the first flowering stage, however, the LAI of bean plants in the weedy environment was less than in the weed-free environment.

The effect of row and plant spacings on LAI in all treatments in the growing season was similar, and increasing row and plant spacings caused a significant reduction in the LAI of pinto bean plants (Table 2). The interaction of row and plant spacing with the LAI at any given growth stage was significant, and increasing plant spacing within rows significantly reduced the LAI of pinto bean plants.

The LAI in treatments with 5 cm plant spacing compared to 10 cm and 15 cm plant spacings was approximately 45 and 58% higher, respectively. The LAI at narrow row widths compared to the LAI of medium and wide rows was 31 and 61% higher in weed-free environments and 34 and 63% in weedy environments, respectively. Other researchers [10, 14, 17, 20] have observed that narrow row spacing and higher seeding density facilitate faster ground coverage.

The LAI of pinto bean was negatively correlated with total weed biomass at the pod formation growth stage (Figure 1). Treatments that allowed the pinto bean to maximize its LAI in the presence of weeds had less accumulation of weed biomass. This supports the work by Malik *et al*. [12] who found that the LAI of white beans was negatively correlated with total weed biomass at pod formation growth stage. Additionally, average plant height, number of branches per plant, and number of main stem nodes at maturity were all negatively correlated with weed biomass accumulation (date not shown).

## Seed Yield

Season-long weed interference greatly reduced the seed yield of pinto beans (Table 3). Under weed-free conditions, the traditional wide rows yielded 15% less than medium or narrow rows. Pinto bean seed yield





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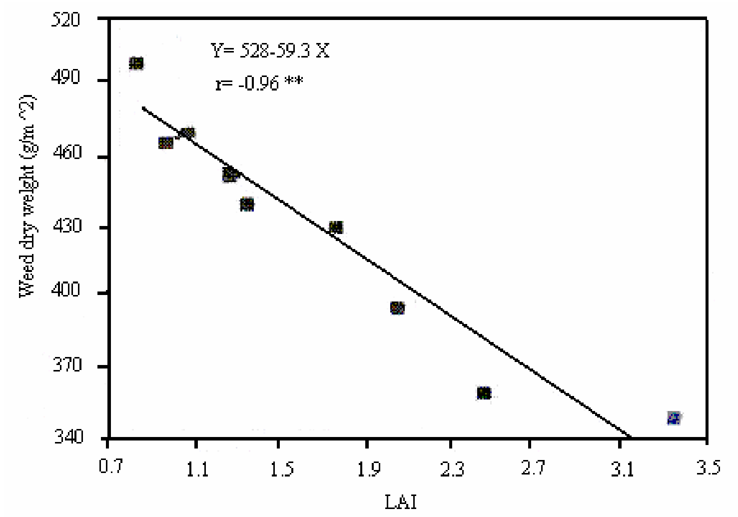


**Figure 1**. Relationship between pinto bean LAI and total weed dry weight at the bean pod filling stage. Asterisks indicate significance of correlation at a 0.01(**) level of probability.

was not different between medium and narrow rows. Differential effects of planting patterns on crop yield have been reported. Some researchers [2, 10, 14, 16] observed no effect of row spacing on white bean or soybean yield when crops were grown under weed-free environments, while others observed a positive yield response under narrow row spacing [7, 8, 12, 17, 21].

Pinto beans planted in traditional wide rows and grown under season-long weed interference yielded 40% less seeds than when planted in medium or narrow rows. This may have been due to a more favorable outcome of weed-crop competition for pinto beans planted in the narrow rows. Other researchers [10, 11, 12, 13, 14, 20] have found that with season-long weed interference, the seed yield of common bean or soybean was reduced by planting in wide rows compared to medium or narrow rows. The yield of pinto beans in medium rows compared to narrow rows in the weedy environment also was reduced by 13%. A reduction in seed yields of common beans or soybean in proportion to the degree of weed interference is

**Table 3**. Pinto bean seed yield as affected by row and plant spacing.

| | Plant spacing within rows (cm) | Row spacing (cm) 45 | 60 | 75 | Mean |
|---|---|---|---|---|---|
| | | ---------------------- Kg ha$^{-1}$ | --------------------- | | |
| Weed-free | 5 | 2298 a A[a] | 2250 a A | 1994 a B | 2181 a |
| | 10 | 2240 ab A | 2170 a A | 1914 a B | 2108 b |
| | 15 | 2193 b A | 2051 b B | 1798 c C | 2014 c |
| | Mean | 2244 A | 2157 A | 1902 B | |
| Weedy | 5 | 1008 a A | 8871 a B | 554 a C | 814 a |
| | 10 | 945 a A | 836 a B | 508 ab C | 763 b |
| | 15 | 863 b A | 740 b B | 447 b C | 683 c |
| | Mean | 939 A | 819 B | 503 C | |

[a] Means within the same row (capital) and column (small) followed by the same letter are not significantly different according to Duncan′s multiple range test (P=0.05)





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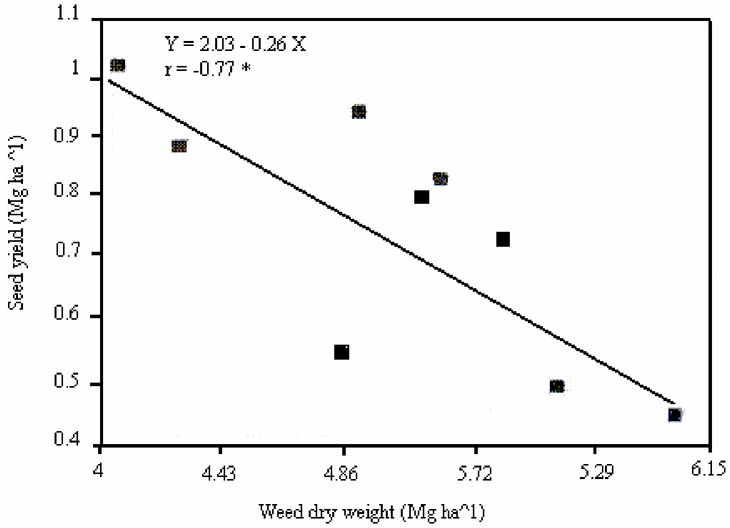


**Figure 2.** Relationship between pinto bean yield and total weed Jry weight at the bean pod maturity stage. Asterisks indicate significance of correlation at a 0.05 (*) level of probability.

well documented [2, 9, 11, 14]. Malik *et al*. [12] found that the production of each kg ha$^{-1}$ of weed biomass resulted in an average white bean yield reduction of 0.38 kg ha$^{-1}$. In this experiment, the yield of pinto beans was negatively correlated with total weed dry weight (Figure 2) and each kg ha$^{-1}$ increase in weed dry weight resulted in a corresponding pinto bean yield loss of 0.26 kg ha$^{-1}$.

Pinto beans planted in 5 cm plant spacings compared to 15 cm plant spacings yielded 8% higher in weed-free environments and 16% in weedy environments. Goulden [7] concluded that under a season-long weed-free environment, varying spacing within the row had little effect on yield of beans. This may be because the impact of pinto bean intraspecific competition was greater than interspecific competition [5].

An interaction between row and plant spacing was observed in both weedy and weed-free environments. Increasing plant spacing from 5 cm to 15 cm within each row significantly reduced pinto bean yield. How-

**Table 4.** Pinto bean number of pods per plant as affected by row and plant spacings.

| | Plant within rows (cm) | Row spacing (cm) 45 | 60 | 75 | Mean |
|---|---|---|---|---|---|
| Weed-free | | | | | |
| | 5 | 10.7 b B[a] | 12.5 b B | 15.4 c A | 12.9 c |
| | 10 | 14.1 a C | 16.2 a B | 20.4 b A | 16.9 b |
| | 15 | 16.4 a B | 18.0 a B | 23.3 a A | 19.3 a |
| | Mean | 13.7 C | 15.6 B | 19.7 A | |
| Weedy | | | | | |
| | 5 | 4.3 b A | 5.4 b A | 6.3 b A | 5.3 b |
| | 10 | 5.9 a B | 7.0 a AB | 8.7 a A | 7.2 a |
| | 15 | 6.7 a B | 7.6 a A | 9.4 a A | 7.9 a |
| | Mean | 5.6 B | 6.7 B | 8.1 A | |

[a] Means within the same row (capital) and column (small) followed by the same letter are not significantly different according to Duncan′s multiple range test (P=0.05)




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**Table 5.** Pinto bean 100-seed weight as affected by row and plant spacings.

| | Plant within rows (cm) | Row spacing (cm) 45 | 60 | 75 | Mean |
|---|---|---|---|---|---|
| | | -------------------------gr------------------------- | | | |
| Weed-free | | | | | |
| | 5 | 32.7 a A[a] | 33.1 a A | 3.4 a A | 33.1 a |
| | 10 | 32.2 a A | 33.5 a A | 33.1 a A | 32.9 a |
| | 15 | 32.9 a A | 33.8 a A | 33.8 a A | 33.5 a |
| | Mean | 32.6 A | 33.5 A | 33.4 A | |
| Weedy | | | | | |
| | 5 | 31.5 a A | 32.3 a A | 32.2 a A | 32.0 a |
| | 10 | 32.1 a A | 31.9 a A | 32.0 a A | 32.0 a |
| | 15 | 31.7 a A | 32.7 a A | 32.5 a A | 32.3 a |
| | Mean | 31.8 A | 32.3 A | 32.2 A | |

[a] Means within the same row (capital) and column (small) followed by the same letter are not significantly different according to Duncan′s multiple range test (P=0.05).

ever, in most cases pinto bean seed yield was not different between 5 cm and 10 cm plant spacings.

### Pods per Plant and Seed Weight

The number of pods per plant and 100-seed weight were reduced by season-long weed interference (Tables 4 and 5). The 100-seed weight and number of seeds per pod (data not shown) were not affected by row and plant spacings. These results are in agreement with work undertaken by Malik *et al* (12) who found that season-long weed interference significantly reduced total number of pods per plant and 100-seed weight. However, row spacing or seeding density had no effect on 100-seed weight and number of seeds per pod. In a weedy environment, there was no difference in number of pods per plant in narrow or medium rows, but in wide rows an increase in the number of pods per plant was noted. In a weedy environment, number of pods per plant was also not different in 10 cm and 15 cm plant spacings. In a weed-free environment, the number of pods per plant increased significantly, as row or plant spacing increased. Other researchers (1,3,4,8,12) have also reported that the number of pods per plant increases by increasing soybean or common bean row width or decreasing plant population.

## CONCLUSION

In conclusion, total weed dry weight was negatively correlated with pinto bean yield. Pinto beans planted in medium and narrow rows were more competitive with weeds than when planted in wide rows. The LAI was found to be a good indicator of weed competition since it started declining at the second trifoliate stage under weed pressures and was negatively correlated with total weed dry weight. Howe and Oliver (10) also concluded that the LAI is a better indicator of weed competition than plant height, net assimilation rate, or relative growth rate. Although the results of this study are critical to the development of new systems for pinto bean management, they do not provide complete information on weed management in narrow rows. Further investigations are required to determine the usefulness and mechanics of herbicide banding and interrow cultivation in narrow rows.

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# اثر فاصله رديف و بوته روي رقابت علفهاي هرز با لوبيا چيتي (*Phaseolus vulgaris* L.)

ح. غديري و م. ل. بيات

## چكيده

براي بررسي توانايي رقابتي لوبيا چيتي (*Phaseolus vulgaris* L. var. Daneshjou) با علفهاي هرز، آزمايشي مزرعه‌اي در سال ۱۳۷۵ در ايستگاه تحقيقاتي دانشكده كشاورزي دانشگاه شيراز واقع در كوشكك انجام شد. در اين مطالعه، براي افزايش توانايي رقابتي لوبيا چيتي، فاصله رديف و بوته‌ها تغيير داده شد. جمعيتهاي كنترل نشده علفهاي هرز عملكرد دانه لوبيا چيتي را تا ۷۵% كاهش دادند. توانايي گياه زراعي براي كاهش وزن خشك علفهاي هرز در رديفهاي متوسط و باريك در مقايسه با رديفهاي پهن افزايش بيشتري يافت. تركيباتي از فاصله رديف و فاصله بوته كه باعث افزايش شاخص سطح برگ گرديد، در شرايط علف هرزي به طور معني‌داري وزن خشك علف هرز كمتري را نيز به همراه داشت. با وجود اين، فاصله رديف و فاصله بوته تراكم علفهاي هرز را كاهش نداد. همبستگي منفي معني‌داري بين وزن خشك علفهاي هرز با شاخص سطح برگ و عملكرد نهايي لوبيا چيتي وجود داشت و به ازاء افزايش هر كيلوگرم در هكتار وزن خشك علفهاي هرز، افت عملكرد لوبيا چيتي به طور متوسط ۲۶۰ گرم در هكتار بود. رقابت علفهاي هرز در طول فصل رشد تعداد كل غلاف در بوته، تعداد دانه در بوته و وزن صد دانه را به طور معني‌داري كاهش داد.





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