Interseeding Snap Pea into Stands of Chile Pepper Reduces Yield of Pea More Than That of Chile

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Additional index words. multiple cropping, relay intercropping, interplanting, *Pisum sativum*, *Capsicum annuum*

Abstract. ‘Sugar Snap’ snap peas (*Pisum sativum* L.) were interseeded into a stand of ‘Española Improved’ chile pepper (*Capsicum annuum* L.) in July or Aug. in 1995, 1996, and 1997. Peas were interseeded as one or two rows per bed, giving planting rates of about 92 or 184 kg·ha⁻¹, respectively. Our objectives were to determine: 1) if intercropped pea would reduce chile yield and vice versa; 2) the effects of pea planting rates and dates on pea yield. Intercropped peas reduced chile yield by about 22% in 1995, but had no significant effects in other years. Pea plants from the August intercrops reached the flowering stage but did not produce pods in 1995 or 1996; some small pods were produced from August intercrops in 1997. Final plant densities were lower and less uniform in 1996 than in 1995 or 1997. Intercropped peas yielded less than monocropped peas in all years. Pea yields ranged from 1370 to 3960 kg·ha⁻¹ when monocropped, 31 kg·ha⁻¹ (1996 single-row) to 646 kg·ha⁻¹ (1995 double-row) when intercropped. In 1995 only, the double-row intercrop yielded more peas than the single-row intercrop. Pod yield/plant was reduced 80%, 98%, and 96% in 1995, 1996, and 1997, respectively, by intercropping. Estimated gross revenues for the treatments indicate that, under the price assumptions used in the study, interseeding snap peas into stands of chile in north-central New Mexico is not economically advantageous compared with monocropped chile.

Relay intercropping is a form of multiple cropping in which a second crop is planted into stands of the first crop when the first crop has reached its reproductive stage but before it is harvested (Andrews and Kassam, 1976). This practice can be used to produce two crops in one year in areas where the growing season is too short for sequential or double cropping. One well-known example of relay intercropping is that of beans (*Phaseolus* spp.) relayed into maize (*Zea mays* L.) (Pinchinat et al., 1976), a practice used by indigenous peoples in the Americas and one that continues to be common in Latin America.

In relay intercropping systems in which the crop species compete significantly with each other for resources, yields of one or both are often less than if each were grown alone. The importance of any yield reductions depends on the value of each crop to the producer. Generally, if both crops are of equal importance, a reduction in yields of both is acceptable if the total yield from both has more economic or food value than if one or both had been monocropped on an equivalent area of land. If one crop is of higher value, the goal is to maintain its yield and produce whatever extra is possible from the secondary crop.

Chile is a frost-sensitive crop that has a growing season limited primarily by the last spring frost and the first fall frost. In regions with climates similar to those of north-central New Mexico, however, the growing season for frost-hardy crops can be considerably longer. Relay intercropping may be a way to produce a fall crop of peas in addition to a chile crop in one year on the same field.

To our knowledge, no research has been reported on relay intercropping of peas and chile. Developing such a system would be particularly beneficial for small landholders, such as those in north-central New Mexico, who need to use land, sunlight, and other on-farm resources as efficiently as possible. A few studies have been reported on intercropping chile with other species, including soy-

bean [*Glycine max* (L.) Merr.] (Hulugalle and Willatt, 1987), other legumes (Guldán et al., 1996), maize and eggplant (*Solanum melongena* L.) (Hussein and Abdul Samad, 1993), and finger millet [*Eleusine coracana* (L.) Gaertn.] (Ramamurthy et al., 1993). Guldán et al. (1996) found that chile yield was not significantly affected by interseeding legumes in August, and that legumes produced more fall growth when interseeded in early August vs. mid-August.

We conducted an experiment in which two planting rates of snap pea were interseeded into chile at two dates in three growing seasons. Our objectives were to determine: 1) if intercropped pea would reduce chile yield and vice versa; 2) the effects of pea planting rates and dates on pea yield.

Materials and Methods

This experiment was conducted at the Sustainable Agriculture Science Center in Alcalde, N.M., (elevation 1740 m) during the 1995, 1996, and 1997 growing seasons on a Fruitland sandy loam [coarse-loamy, mixed (calcareous), mesic Typic Torriorthent]. Separate field sites were chosen for 1995 and 1996. The field site used for the 1995 trial was seeded to a cover crop of winter wheat in 1996 and then used again for the 1997 trial site. Seedbed preparation in the field was achieved by disking the soil, making rough beds with a lister plow (a small, double moldboard plow), and then using a rolling cultivator to make loose beds about 18 cm high and rounded at the top. The centers of the beds were 91 cm apart. Diammonium phosphate (18N–20.2P–0K) was broadcast to provide 66 and 74 kg·ha⁻¹ N and P, respectively, and was cultivated lightly into the soil the day before transplanting.

Uniform, 13-week-old, ‘Española Improved’ chile plants were hand-transplanted on the prepared beds on 15 June 1995, and 17 June 1996 and 1997. Two plants 7–10 cm in height were placed together every 30 cm. Treatment plots were four rows wide and 4.6 m long. Chile plants were furrow-irrigated immediately after transplanting and as needed thereafter; depending on rainfall, plots were generally irrigated every 1 to 3 weeks during the growing season. Weeds were controlled with a row-crop cultivator and hand weeding. The first fall temperature of 0 °C or lower occurred on 3 Oct. 1995, 29 Sept. 1996, and 9 Oct. 1997. The first fall temperature of –2 °C or lower occurred on 6 Oct. 1995, 18 Oct. 1996, and 13 Oct. 1997.

On 20 July 1995, 23 July 1996, and 25 July 1997, and on 11 Aug. 1995, 13 Aug. 1996, and 14 Aug. 1997, ‘Sugar Snap’ edible-pod peas were inoculated with the appropriate *Rhizobium* spp. and planted in one or two rows along the chile plants. Single-row and double-row plantings resulted in planting rates on a pure live seed basis of about 92 and 184 kg·ha⁻¹, respectively. Single-row plantings were placed about 8 cm from the chile row on the west side of the north–south oriented rows, while double-row plantings were placed the same 8 cm distance from the chile plants, but to each side

Received for publication 28 May 1997. Accepted for publication 8 Jan. 1998. A contribution of the New Mexico Agricultural Experiment Station, New Mexico State Univ., Las Cruces. We gratefully acknowledge the technical assistance of David J. Archuleta and Val S. Archuleta, and office assistance from Phyllis Moya, Dora Valdez, and Augusta Archuleta. Use of trade names does not imply endorsement of the products named nor criticism of similar ones not named. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

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of the row. Hand hoes were used to cut grooves in the soil 6–8 cm deep for the seed, which was evenly hand-dropped into the open grooves. After placement, the seeds were covered with soil to a final depth of 5–7 cm. During the July interseedings chile plants were at the late vegetative stage in 1995 and at the initial flowering stage in 1996 and 1997. During the August interseedings they were generally at flowering and early-pod development in all years. Pea seedlings began to emerge 7–10 d after planting. Monocropped plots of pea at each pea planting rate were also established at the same times as the interseeded peas.

The design was a randomized complete block design with four replications. Variables were pea planting rate and planting date. Control treatments of monocropped pea and chile were also included.

The first and only chile harvest of the 1995 season was made on 7 Sept. Chile was harvested on 26 Aug. and 19 Sept. 1996 and on 15 Sept. and 9 Oct. 1997. Green mature pods were harvested from a 3-m length from each of the two middle rows of each plot, and fresh mass was recorded. Pea pods were harvested on 26 Sept. and 10 Oct. 1995, 7 Oct. and 5 Nov. 1996, and 6 Oct. and 14 Nov. 1997 from a 3-m length from each of the two middle beds (one pea row per bed for the low pea planting rate and two rows per bed for the high rate) of each plot. Fresh mass was recorded and, for a given plot, consisted of both “full” and “flat” (“snowpea” type) pods. At the last pea harvest in each year, plant counts were taken from the same sample areas used for pea-pod harvests.

Analysis of variance was performed on the plant data using the General Linear Models procedure (SAS Institute, 1996). An F test ($P \leq 0.05$) indicated that variances for chile yield/ha, pea yield/ha, and pea yield/plant were significantly different among years; therefore, these data were analyzed separately for each year. Pea plant count data were also analyzed separately for each year to correspond with the presentation of pea yield data. Single degree of freedom planned F tests were used for between-group and within-group treatment comparisons. Mention of significance in the text refers to $P \leq 0.05$ unless otherwise stated.

Estimated gross revenues were calculated for the 3 years of the experiment for monocrop and intercrop treatments. Two pea pricing assumptions were used: average minimum and maximum prices for the years of the experiment, as published by the U.S. Dept. of Agriculture Agricultural Marketing Service Fruit and Vegetable Market News Service. The Fruit and Vegetable Terminal Market Prices series as published by the Univ. of Florida (<http://mis.ifas.ufl.edu/~market/market.html>) were used in the analysis. Average minimum and maximum prices were calculated for a period of time close to the harvest dates of the experiments. Sugar snap pea prices were average minimum and maximum wholesale prices at the Los Angeles terminal market from 27 Sept. to 29 Nov. 1995, and from 7 Oct. to 8 Nov. 1996. In 1997, historical prices had not yet been posted on the website. However, each day's current prices were posted. Therefore, the minimum and maximum daily Los

Angeles price for 5 Dec. 1997 was used for the 1997 price. The maximum prices used were \$3.87, \$6.03, and \$3.97/kg, and the minimum prices \$3.41, \$5.67, and \$3.53/kg for 1995, 1996, and 1997, respectively.

The chile prices used (\$1.52/kg in 1995 and \$1.90/kg in 1996 and 1997) were obtained from estimates of prices received by farmers in Rio Arriba County, in which the experiment took place.

Results and Discussion

Chile yields were lower in 1995 than in 1996 and 1997 (Table 1), because only one harvest was made in 1995 before onset of cooler temperatures and the first fall frosts. Averaged across single- and double-row pea intercrop treatments and across July and August pea plantings, intercropped peas significantly reduced chile yield by $\approx 22\%$ in 1995. However, double rows had no more effect than single rows. Intercropping peas had no effect on chile yield in 1996 and 1997.

In 1995 and 1996, pea plants from the August-seeded intercrops did not produce pods by the end of the growing season. Plants reached the flowering stage, but the cool temperatures and frosts prevented any further reproductive development. In 1997, pods began developing on August-seeded peas by the end of the growing season, but they were too small to be marketable. Therefore, all pea data presented are from the July-seeded peas.

The reduction of chile yield by pea intercropping in 1995 but not 1996 or 1997 may have been related to differences in pea plant density. In 1995, but not 1996 or 1997, pea plant density was significantly higher for double-row vs. single-row intercrops (Table 2). Pea plant densities in intercrops were generally lower in 1996 and 1997 than in 1995, and densities of the single-row intercrops did not differ significantly from those of double-row intercrops in 1996 and 1997. The contrast of monocrop vs. intercrop was significant only in 1997 (Table 2), indicating that the chile plants may have reduced establishment of the peas in that year; however, we are uncertain why this effect occurred only in 1997.

Intercropping with chile reduced pea-pod yield in all years as indicated by the significant contrasts of monocrop vs. intercrop (Table 2). In 1995, but not in 1996 or 1997, pod yield was

Table 1. Effects of intercropping vs. monocropping on yield of chile. Data are cumulative seasonal yields averaged across pea intercropping dates.

Treatment	Chile-pod fresh mass (Mg·ha ⁻¹)		
	Year		
	1995	1996	1997
Monocrop	7.48	18.62	12.87
Intercrop, one pea row/bed ²	5.22	16.58	13.00
Intercrop, two pea rows/bed ²	6.40	17.26	14.07
Planned comparisons			
Chile monocrop vs. chile-pea intercrop	*	NS	NS
Intercrop, one pea row/bed vs. intercrop, two pea rows/bed	NS	NS	NS

²Equivalent to a planting rate of ≈ 92 kg·ha⁻¹.

³Equivalent to a planting rate of ≈ 184 kg·ha⁻¹.

NS, *Nonsignificant or significant at $P \leq 0.05$.

Table 2. Pea plant density, cumulative pod yield/ha, and pod yield/plant; data from July pea plantings only.

Treatment	Plants/ha (1000)			Pod fresh mass (kg·ha ⁻¹) ²			Pod fresh mass (g/plant) ²		
	1995	1996	1997	1995	1996	1997	1995	1996	1997
Monocrop									
One row/bed ²	84.3	59.2	140.3	1370	1880	3140	18	45	27
Two rows/bed ³	126.0	58.7	187.4	1930	1520	3960	17	85	23
Intercrop									
One row/bed	57.4	43.5	57.4	167	31	70	3	1	1
Two rows/bed	173.5	50.6	97.3	646	56	61	4	2	1
Planned comparisons									
Monocrop vs. intercrop	NS	NS	**	**	**	**	**	**	**
One- vs. two-row	**	NS	*	**	NS	NS	NS	*	NS
Intercrop, one- vs. two-row	**	NS	NS	**	NS	NS	NS	NS	NS

²Data represent combined total of flat- and full-pod peas.

³One pea row/bed is equivalent to a planting rate of ≈ 92 kg·ha⁻¹.

⁴Two pea rows/bed are equivalent to a planting rate of ≈ 184 kg·ha⁻¹.

NS, **, *Nonsignificant or significant at $P \leq 0.05$ or 0.01.

Table 3. Estimated gross revenues for chile and pea monocrop vs. intercrop treatments.

Pea-pod price assumption and treatment	Estimated gross revenues (U.S.\$/ha)		
	Year		
	1995	1996	1997
Maximum prices			
Chile monocrop	11,385	35,302	24,397
Pea monocrop, one row/bed ^a	5,287	11,355	12,472
Pea monocrop, two rows/bed ^b	7,479	9,176	15,705
Chile-pea intercrop, one pea row/bed	8,398	31,630	24,934
Chile-pea intercrop, two pea rows/bed	12,236	33,071	26,916
Minimum prices			
Chile monocrop	11,385	35,302	24,397
Pea monocrop, one row/bed ^a	4,652	10,682	11,083
Pea monocrop, two rows/bed ^b	6,579	8,633	13,957
Chile-pea intercrop, one pea row/bed	8,320	31,619	24,903
Chile-pea intercrop, two pea rows/bed	11,936	33,051	26,889

^aEquivalent to a planting rate of $\approx 92 \text{ kg} \cdot \text{ha}^{-1}$.^bEquivalent to a planting rate of $\approx 184 \text{ kg} \cdot \text{ha}^{-1}$.

significantly higher for double- vs. single-row intercrops whether compared across monocrop and intercrop pea treatments, or only across the intercropped peas (Table 2). This is generally consistent with the pea plant density results, where the difference in plant density between the double-row and single-row treatments was relatively greater in 1995 than in 1996 or 1997.

In all years, pea-pod yield/plant was significantly lower (80%, 98%, and 96% lower in 1995, 1996, and 1997, respectively) for intercropped vs. monocropped peas (Table 2). Only in 1996, when averaged across monocrop and intercrop pea treatments, was there a significant difference in pod yield/plant between single- and double-row treatments. Monocropped peas apparently were able to compensate for lower plant densities in 1996 by pro-

ducing more per plant. However, intercropped peas were not able to compensate, resulting in very low yields on a per-hectare basis in 1996 (Table 2).

Gross revenues were not affected greatly by pea pricing assumption (Table 3). Except for the double-row intercrop in 1997, gross revenues for intercrops were similar to or somewhat lower than for monocropped chile. Subtracting pea seed costs (\$557 to \$607/ha for single-row peas and \$1113 to \$1214/ha for double-row peas, depending on year) leaves only the 1997 double-row pea intercrop treatment with a slight gain in revenue compared to monocropped chile. Even if labor costs were minimal (in north-central New Mexico small family farms commonly use family labor for planting and harvesting), economic loss appears to be more probable than gain by

interseeding peas into stands of chile under the field conditions and price assumptions of this study. The productivity and profitability of this system might be improved by using other pea and/or chile cultivars or pea planting dates; this could be the subject of additional research.

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