Yields of Bell Pepper, Sweet Corn, and Peanut in Rotations

Vincent M. Russo
U.S. Department of Agriculture, Agricultural Research Service, South Central Agricultural Research Laboratory, P.O. Box 159, Lane, OK 74555

Additional index words: culture, vegetables, peanut marketable rating

Abstract. Abiotic and biotic factors, and government farm policy, affect peanut (Arachis hypogaea L.) production especially in the Southern Plains of the United States. A coincident increase in vegetable production has led to interest in diversification of production on land that has historically supported peanut. A multi-year experiment was conducted from 1998 to 2001 to determine how rotating bell pepper (Capsicum annuum var. annuum L.) and sweet corn (Zea mays L.) with peanut affect yields of all three crops. In the first year, the site was planted to peanut, except for those areas of the field that would have monocultured bell pepper or sweet corn throughout the experiment. In following years, parts of the field that were planted with peanut were planted with either either, bell pepper, or sweet corn. Except for the monocultured crops, plots had 2 years of peanut and one year each of bell pepper or sweet corn in one of four rotations. Yields were determined and terminal market value was assigned to crops. Cumulative yields for monocultured bell pepper and sweet corn were 27.8 and 22.8 Mg·ha⁻¹ after 4 years. The best yield of bell pepper or sweet corn in any rotation was 15.3 or 11.3 Mg·ha⁻¹, respectively. Rotation did not affect peanuts, and cumulative yields for monocultured peanut were 8.39 Mg·ha⁻¹ and averaged 2.13 Mg·ha⁻¹ per year in rotations. Cumulative yields for all crops in rotations where vegetables were planted in the last 2 years averaged 21.5 Mg·ha⁻¹ as opposed to 13.8 Mg·ha⁻¹ when vegetables were planted in the middle 2 years of a 4-year rotation. Yields of all crops were modified by environmental conditions, and terminal market price affected crop value so that high yields were not always associated with high returns.

Interest in rotating peanut (Arachis hypogaea L.) with other crops, and in diversifying production on peanut land in the Southern Plains of the United States, has increased because monoculture of peanut can lead to reduced yield (Akem et al., 1992; Bell and Sumner, 1984), and peanut are subject to changes in the national farm support system in the United States (Hoover and Sumner, 1985). In many peanut production areas in the United States, multiple cropping is possible (Sumner et al., 1978, 1979). Vegetables often have low yields following peanut as compared to following other vegetables (Sumner et al., 1983). In those trials, vegetables were planted in the same growing season as peanut. Russo (1997) determined that when bell pepper (Capsicum annuum var. annuum L.), dry bean (Phaseolus vulgaris L.) or cucumber (Cucumis sativus L.) followed by peanut in annual rotations, and the soil was covered with annual Italian ryegrass (Lolium multiflorum Lam.) during the overwintering period, vegetable yields declined over time. The best rotation sequence that will improve the yield of vegetables produced in rotation with peanut remains to be determined.

Brenneman et al. (1995) found that yields of peanut and Pensacola bahiagrass (Paspalum notatum Flügge) were increased when they were grown in rotation. Since sweet corn (Zea mays L.) is also a monocot, with presumably some of the qualities that make other monocots a good component in rotations with peanut, it may be a viable addition to a rotation of peanut with other vegetables. Crop rotation will allow the diversification of land currently in peanut production, and provide producers with more flexibility. This experiment was designed to determine how yields of bell pepper, sweet corn, or peanut were affected by annual rotations as affected by monoculture.

Materials and Methods

The experiment was conducted at Lane, Okla., on a Bernow fine-loamy, siliceous, thermic Gliosochre Paleudalf soil that was left fallow for a year prior to the first planting. In 1998, a 0.7-ha area was plowed, disked, and fertilizer with 112N–180P–450K kg·ha⁻¹ was applied as a broadcast preplant. These amounts were based on results of soil tests to bring levels to those that would support vegetables (Motes and Roberts, 1994). The source of N was ammonium nitrate, P was phosphoric acid, and K was muriate of potash. This amount of the combined fertilizer was sufficient to support peanuts according to Oklahoma State Univ. recommendations (Sholar et al., 1996). Russo (1991) found that a single preplant application of a combined N–P–K fertilizer was sufficient to produce acceptable yields for bell pepper. Beds on 9.0 m centers were constructed in each year with a rolling cultivator and were 25 cm high and 8 cm across at the rounded top. The entire area, with the exception of those plots that would be planted to monocultures of bell pepper or sweet corn, was planted with ‘Spanco’ peanut.

In the years following 1998, the area planted initially to peanut was subdivided into plots, each of which was assigned to either one of four rotations, or a monoculture check which was planted to bell pepper, or sweet corn or peanut (Table 1). Each plot was 9.1 m wide x 23 m long, with 10 treatment rows oriented east to west. Guard rows of either peanut or vegetables were on the north and south sides of plots. Plots were planted with either 6-week-old greenhouse grown seedlings of ‘Bell Captain’ bell pepper using a vegetable transplanter (Holland Transplant Co., Holland, Mich.), or direct seeded with ‘Summer Sweet 7630Y’ sweet corn, or ‘Spanco’ peanut, both of which were planted with a vacuum planter (Monosem NG, ATL, Lenexa, Kans.). In-row spacing was 46 cm for bell peppers, 23 cm for sweet corn, and 6.4 cm for peanut. The experimental design was a randomized complete block with combinations of rotations (4) and monoculture (3) making up the whole plot treatments within blocks which were replicated four times in each year.

The herbicide e.e.e.-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine (trifluralin) was applied to preplant soil that was to be planted to bell pepper and peanut, and 2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1- methyl) acetamide (metolachlor) was applied post emergence to soil which was to be planted with sweet corn to control weeds. Sweet corn was treated with a Bacillus thuringiensis-containing insecticide at the first sign of silk elongation, and additionally at 5-day intervals until silks were brown. Tetrachlorothio-sophathalolinitrile (chlorothalonil) was applied when symptoms of fungal colonization were observed on peanut foliage, and alternated with

<table>
<thead>
<tr>
<th>Year</th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monoculture bell pepper</td>
<td>BP</td>
<td>BP</td>
<td>BP</td>
<td>BP</td>
</tr>
<tr>
<td>Monoculture sweet corn</td>
<td>SC</td>
<td>SC</td>
<td>SC</td>
<td>SC</td>
</tr>
<tr>
<td>Monoculture peanut</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>Rotation 1</td>
<td>P</td>
<td>P</td>
<td>SC</td>
<td>BP</td>
</tr>
<tr>
<td>Rotation 2</td>
<td>P</td>
<td>P</td>
<td>BP</td>
<td>SC</td>
</tr>
<tr>
<td>Rotation 3</td>
<td>P</td>
<td>SC</td>
<td>BP</td>
<td>P</td>
</tr>
<tr>
<td>Rotation 4</td>
<td>P</td>
<td>BP</td>
<td>SC</td>
<td>P</td>
</tr>
</tbody>
</table>

Abbreviations: BP = bell pepper; P = peanut; and SC = sweet corn.

Received for publication 29 July 2002. Accepted for publication 15 Sept. 2003. Mention of a trademark, vendor, or proprietary product does not constitute a guarantee or warranty of the product by the USDA and does not imply its approval to the exclusion of other products that may also be suitable.

HORTScience, Vol. 38(7), December 2003
F test for post hoc means separation. 

subjected to the Ryan–Einot–Gabriel–Welsch 

Institute, 2001). Where appropriate, data were 
general linear models procedures in SAS (SAS 
and SMK rating. Data were analyzed by the 
price for an “average rating” based on yield 
support price for peanut which represents the 
bell pepper and sweet corn were averages of 
market prices are reported by the USDA, ARS, 
ods during which harvests occurred. Terminal 
peanut were determined.

• 
• 

ranges, number of nights with temperatures 
rains occurring after harvest of peanuts made 
field in each year, except for 1998, when heavy 
removal of peanut hay impossible. 
Total precipitation for the growing period, 
average high and low air temperatures and their 
ranges, number of nights with temperatures 
±22 °C, and number of days with temperatures 
±38 °C, and days to first harvest for each crop 
were tabulated (Table 2). Yields for bell pepper 
or sweet corn only, the combined yields 
for bell pepper and sweet corn, the yield for 
peanut only, and cumulative yields of all crops 
in rotations, as well as the SMK rating for 
peanut were determined. 
Terminal market prices for vegetables at 
the Dallas market were determined for peri-
dods during which harvests occurred. Terminal 
market prices are reported by the USDA, ARS, 
Agricultural Marketing Service as ranges based 
on number and quality of products. Prices for 
bell pepper and sweet corn were averages of 
terminal market prices during the harvest period 
for each crop. Peanut value was based on the 
support price for peanut which represents the 
price for an “average rating” based on yield 
and SMK rating. Data were analyzed by the 
general linear model procedures in SAS (SAS 
Institute, 2001). Where appropriate, data 
were subjected to the Ryan–Einot–Gabriel–Welsch 
F test for post hoc means separation. 
The years 1998 to 2001 varied in weather 
conditions (Table 2). Days to harvest in 
1998 to 2001 were different for all crops 
in rotations. Total precipitation was highest 
in peanut in 1999 and 2001 and for bell 
pepper and sweet corn in 1999. For peanut 
the number of nights with temperatures ±22 
°C during the growing seasons decreased from 1998 to 2001 and there were fewer 
days with temperatures ±38 °C in 1999 and 
2000 than in 1998 and 2001. For bell pepper 
the number of nights with temperatures ±22 
°C was highest during the 2000 growing 
season, and for sweet corn the number of 
nights with temperatures ±22 °C was least in 
2001. There were few days with temperatures 
±38 °C for the bell pepper and sweet corn 
growing season.

Distribution of yields and terminal market 
prices for each crop within the plantings are 
presented in Table 3. The cumulative terminal 
market prices for rotation 1 and 2 were both 
less than for monocultured bell pepper, and 
for rotation 2 less than for monocultured bell 
pepper and sweet corn. Rotation 3 had the 
lowest total market value. Rotation 4, which had 
less cumulative yield than other rotations, had 
a total market value similar to that for rotation 
2. This was due to the confluence of yield and 
value of bell pepper.

Analysis of variance indicated that rota-
tion affected yields of individual vegetables, 
combined yields for bell pepper and sweet corn, 
and cumulative yields for all crops in 
rotations and for crops in monoculture (Table 
4). Peanut yield and SMK rating were not 
affected by planting strategy (rotation vs. 
monoculture) and averaged 2.13 Mg ha⁻¹ and 
66.5%, respectively. Cumulative peanut yield 
in monoculture was 8.39 Mg ha⁻¹. In rotation, 
the yield for bell pepper was highest for rotation 
1 followed by rotation 4, and for sweet corn, 
yield was highest for rotation 2. The combined 
yields for bell pepper and sweet corn, and 
the total cumulative yield of all crops (bell 
pepper, sweet corn and peanuts) in rotation, 
were highest in rotation 1 and 2 followed by 
rotation 4. The monoculture of bell pepper 
and sweet corn produced cumulative yields 
that were similar to cumulative yields for the 
best rotations.

In multiple year rotations, or monoculture 
over several years, expression of plant devel-
opment and yields are in part, the result of the 
fluences of biotic and abiotic factors. Mono-
culture can bring about changes in soil pH and 
tilth, residual nutrients, and in populations of 
disease and beneficial organisms (Shipper et 
a., 1987; Shiport, 1977). In some cases, rota-
tion of crops can be used to improve yield of 
some or all crops in a rotation (Curl, 1963; 
Russo, 1997; Summer, 1984). Rotation affected 
yield, and results appeared to be modified by 
environmental conditions.

Vegetable (Pierce, 1987) and peanut 
(Bagnall and King, 1991) flower production 
and retention can be adversely affected by air 
temperature. The occasionally higher market-
able yields for bell pepper and sweet corn are 
likely explained by the coincidence by the 
year in the rotation and conducive weather. 
For bell pepper, Rylski (1973) determined 
that temperature affected fruit development, 
and for some time it has been known that high 
night temperatures were detrimental to flower 
and fruit retention (Cochnor, 1952; Deli and 
Tiessen, 1969). It is likely that it is the time 
in the plant’s development that the high night 
temperatures occur, rather than the number 
of nights with high temperatures, that effect 
fruit development in pepper. Since high night 
temperatures likely did not occur when most 
pepper flowers and fruit were being formed, 
the damage to yield was minimized. It may also 
be that higher night temperatures occurring 
during fruit filling might be beneficial to yield 
if adequate water is provided to plants. For 
peanut the number of nights with temperatures 
±22 °C may have affected yield, and would be 
in agreement with Bagnall and King (1991) 
who reported that high night temperatures are 
detrimental to peanut flower production and 
retention.

Cumulative yields for vegetables in rota-
tions 1 and 2 were among the highest. The ca-
pacity to produce high yields under conducive 
environmental conditions allowed bell pepper 
and sweet corn to contribute to higher cumu-
lative yields. Peanut in the rotations yielded 
at a consistent rate. Increases in cumulative 
yields in the rotations were due to contribu-
tions of bell pepper and sweet corn rather than
peanut. This was true for bell pepper or sweet corn in the fourth year of the rotation 1 and 2. However, that may have been due to the weather conditions, since yields of bell pepper and sweet corn in monoculture in that same year were also high.

It appears that monoculture of pepper and sweet corn for up to 4 years at this location is not detrimental to yield, suggesting that pressure from disease organisms was not a major concern. Russo (1997) found that in other rotations with peanut that the population of sclerotia of soilborne fungi was not related to yields of pepper following peanut. Historically there has been little pressure from insects and disease affecting yield of bell pepper at this location. Although monoculture of the vegetables produced some of the best yields it may be that biotic factors leading to stress on the plant might build up over a longer period than that tested.

Perennial Italian ryegrass (L. perenne L.) can interfere, principally through density, with yield of some vegetables (Bell, 1995). It did not appear that annual Italian ryegrass caused a problem due to allelopathy or any other mechanism. That the peanut hay was not removed after the 1998 harvest did not appear to create problems since peanut yields in 1999 in those same plots were generally unchanged. It is difficult to make a judgement concerning the effect of incorporated peanut residue on the vegetables that followed in the next growing season since this occurrence was unplanned and there was no control for comparison.

The expected yield for crops, and their expected value as returns to the producer, are factors on which production decisions are made. Summer (1994) stated that use of some crops in rotations may not be profitable due, in part, to economic factors. In all cases, vegetable production returned greater value than monoculture peanut. The valuation of crops in rotation 1 were similar to those of monocultured vegetables. However, some of this valuation was due to support prices for peanut. The support price for peanut was reduced to $720/Mg in 2002 and when set Fall 2003 is projected to be unchanged or lower. It appears that peanut producers should consider the use of rotation with vegetables. The use of rotations can lead to diversification that is key to the goal of attaining sustainable production.

### Literature Cited


