Effects of Irrigation on Growth, Yield, and Quality of Peas for Processing[1]

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Abstract. Irrigation water was applied at various growth stages to peas (*Pisum sativum* L.) grown for processing. Irrigation increased all growth characters measured, extended blooming and pod setting, and delayed maturity 1 to 7 days. Irrigation at pod filling increased yield more than irrigation at any other growth stage and produced the greatest yield increase per cm of water applied. Irrigated peas were of lower quality for processing than non-irrigated peas.

Improvements in sprinkler irrigation systems in the last decade have resulted in increased irrigation of peas for processing. Ideally, the water supply is efficiently used, yield is increased, and the quality of the harvested crop is maintained or improved. Crop failures caused by occasional extremely hot, dry weather should be reduced.

Studies of moisture regimes during the growth of peas have shown that the period most sensitive to moisture stress is from blossom to harvest (10, 11). Irrigation at the start of flowering and at pod fill produced the greatest yield increase (1, 3, 4, 10, 14). A continuous high level of available water during all stages of growth produced more vine growth but did not increase pea yields proportionately (10, 13). Plants in the high moisture regime tend to continue growth and bloom until harvest (10). Yield of canning peas increased as the amount of water applied increased to 25 cm; 30 cm of water produced slightly less peas than 25 cm (6). Soil moisture tensions not greater than 0.30-0.50 bars for canning peas are recommended (8).

Pea yield increase resulting from supplying supplemental water were attributed to more pods per vine (10, 13, 15) and more peas per pod (10, 13).

Several factors – tenderness, sieve size, color, appearance, and uniformity of size – are involved in the quality of processing peas (7, 9, 17). Tenderness, sieve size, yield, and maturity, especially within a cultivar, are closely related. As peas mature, yield and sieve size increase while tenderness is reduced rapidly (7, 12, 15). Light yellowish-green peas, commonly called "blondes", detract from the table appearance of green peas and result in lower processed grades. The blonde color results from shading of pods (2, 16). Excess vine growth, encouraged by a high level of moisture, would be expected to increase blonde color. Smittle and Bradley (15) reported better color and more chlorophyll in non-irrigated than in irrigated peas.

The experiments reported here were designed to further elaborate the effects of supplemental water on growth, yield, and quality of peas grown for processing.

Materials and Methods

Irrigation experiments were conducted for 4 consecutive years at different locations in the pea production area northeast of Pendleton, Oregon. The annual winter rainfall of 30-35 cm (12-14 inches) filled 90 cm or more of the soil with water by planting time in early April. The Walla Walla and Palouse silt loam Haploxeroll soils hold nearly 5.5 cm of available water in the surface 30 cm and 4.5, 4.2, and 4.4 cm in the 30-60, 60-90, and 90-120 cm depths respectively. Soil moisture was monitored by using gypsum blocks at 15, 30, 60, and 90 cm depths and by soil sampling for gravimetric analysis. Average rainfall in May and June is approximately 0.3 and 0.2 of pan evaporation respectively.

Water was applied by stage of plant growth. Most of the applications were during blooming and/or pod filling. Sufficient water was applied in each irrigation to fill the surface 20 to 40 cm of soil. Treatments used in each experiment are presented in Table 1.

Treatments were arranged in a completely randomized block with 2 replications in the first experiment and 3 replications in subsequent experiments. Individual plots were 9.1 x 12.2 m or larger with sufficient border to prevent overlapping of sprinkler water onto adjacent plots. 'Dark Skinned Perfection' pea was planted in early April each year.

Twenty or more plants were randomly selected at harvest time from each plot for determination of vine length, total pods per vine, pods containing marketable peas and marketable peas per pod (5). Peas were harvested when they were near a tenderometer value of 100 except in the first experiment when all plots were harvested at the same time. For yield, 3 or more samples of 4.5 m^2 were harvested from each plot. Vines were cut below the second node and weighed immediately. The green peas were shelled out in a viner, weighed, and tenderometer readings were taken.

Samples of green peas from each plot in the last 2 experiments were subjected to several tests designed to estimate quality and grade. Samples were frozen, stored for several months, and evaluated by professional graders.

All applicable data accumulated over 21 years at the Pendleton Experiment Station were used to develop a pea yield-tenderometer relationship. This relationship, which was similar to that developed by Norton et al (12), was used to adjust yields to 100 tenderometer. Adjusted yields are used throughout this report.

Results and Discussion

Plant growth. Irrigation had definite effects on vine growth, blooming, maturity, and number of pods per vine. Vegetative growth, as measured by vine length and fresh wt of plant tops, was heaviest where the most irrigation water was applied, with lesser effects from lesser amounts of water (Table 1). The blooming and pod setting stage of growth was as much as 6 days longer where peas were irrigated the most. Irrigated peas matured later than non-irrigated peas by 1 to 7 days. Maturity was latest each year where the peas were irrigated the greatest number of times.

Irrigation increased the number of pods per plant by over 50 percent but did not increase pods containing marketable peas to that extent (Table 1). Many of the additional pods were immature and did not contain marketable peas. Less vine growth and more pods with marketable peas were associated with irrigation during the later stages of growth compared to

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Table 1. Effects of irrigation at different growth stages on plant growth and harvest rate.

Year and growth stage when irrigated	Plant length	Plant wt[z]	Pods/ plant	Pods with marketable peas/plant	Marketable peas/pod	Date harvested
	cm	kg/ha				
1969						
not irrigated	–	16,480	3.3	–	–	June 10
bl-pfi[y]	–	22,510	5.0	–	–	June 10
pfi	–	20,740	4.2	–	–	June 10
1970						
not irrigated	48	15,500	2.5	2.3	5.4	June 26
pre-bl-pfl-pfi	73	28,650	3.8	2.4	6.7	June 28
bl-pfi	62	21,930	3.9	2.5	6.2	June 27
LSD 5%	7	5,260	0.8	NS	1.0	
1971						
not irrigated	104	32,420	2.8	2.6	4.5	July 10
pfi	112	50,410	4.3	3.8	5.3	July 14
pre-bl	122	43,250	4.8	4.1	4.7	July 17
pre-bl-pfi	130	55,480	5.1	4.1	5.0	July 17
pre-pfi	114	48,920	4.7	4.0	4.9	July 17
bl-pfi	107	50,880	4.5	4.0	5.0	July 15
LSD 5%	9	8,200	0.9	0.5	0.2	
1972						
not irrigated	81	17,050	3.1	3.0	5.1	July 4
pfi	94	36,220	4.7	3.7	5.3	July 6
bl	97	36,130	5.4	4.6	4.6	July 6
pre-bl-pfi	109	47,250	6.4	4.4	4.8	July 8
pre-pfi	98	39,220	5.3	4.2	4.8	July 7
bl-pfi	100	44,220	5.7	4.8	5.1	July 7
LSD 5%	19	7,930	1.1	0.7	NS	

[z]Plant wt (green vines and peas) handled in harvesting operations.

[y]Pre-prebloom, bl-blooming, pfl-pods flat, and pfi-pods filling.

irrigation earlier or at several growth stages.

Irrigation did not consistently increase the number of marketable peas per pod (Table 1). Irrigation when pods were filling increased the number of marketable peas per pod more than irrigations earlier in the growing season.

Table 2. Tenderometer readings of peas when harvested, adjusted pea yields as effected by irrigation regimes, and yield increase per cm of water applied.

Year and growth stage when irrigated	Tenderometer readings	Pea yields adjusted to 100 tenderometer	Yield increase per cm water applied
		kg/ha	kg/ha
1969			
not irrigated	101	3,670	–
bl-pfi[z]	85	6,600	320
pfi	87	6,230	470
LSD 10%		2,100	
1970			
not irrigated	92	2,760	–
pre-bl-pfl-pfi	90	4,100	60
bl-pfi	94	3,420	50
LSD 5%		480	
1971			
not irrigated	96	5,380	–
pfi	95	9,580	930
pre-bl	106	7,930	310
pre-bl-pfi	97	9,110	290
pre-pfi	104	9,030	430
bl-pfi	99	10,070	530
LSD 5%		1,130	
1972			
not irrigated	103	5,360	–
pfi	99	7,670	510
bl	104	7,070	380
pre-bl-pfi	96	8,610	240
pre-pfi	103	7,720	260
bl-pfi	103	8,460	340
LSD 5%		710	

[z]Pre-prebloom, bl-blooming, pfl-pods flat, and pfi-pods filling.

Yield. All irrigation treatments increased yields (Table 2). In each experiment the highest yield resulted from the most water application with one exception. In that case the heaviest irrigation rate produced such heavy vine growth that the lower parts of the stems deteriorated from the development of molds.

Irrigation when pods were filling increased yields more than irrigation at any other growth stage (Table 2). The average yield increase with only one irrigation at pod filling was 3,020 kilograms per hectare. Irrigation at pod filling increased yield as much as the combination of irrigation at both prebloom and filling. Irrigation at blooming and filling consistently produced more peas than irrigation only at filling.

Yield increase per cm of water applied was largest where the peas were irrigated only at pod filling and was lowest where the peas were supplied with the most irrigation water (Table 2). Prebloom irrigation was the least effective in increasing yield per cm of water applied.

Irrigation generally increased the ratio of vines to peas, but this was not consistent. Irrigation prior to bloom increased the vine-pea ratio more than irrigation at any other growth stage. This increase of the vine-pea ratio is undesirable because the efficiency of harvest machinery is reduced.

Quality. Irrigation did not improve any measured quality factor and did have serious undesirable effects. Non-irrigated peas had less than 2 percent variation in pea size (uniformity of size test) and were rated near maximum in color score and color intensity. Irrigated peas were less uniform in size and maturity, were more variable in color, rated lower in color score, and contained more blonde peas. The accumulation of these inferior qualities reduced the grade to less than Grade A. When these inferior qualities were a maximum, the peas were rated Substandard grade.

Growth stage at which an irrigation was applied did not influence the effects on quality. Peas irrigated at more than 1 stage were more variable in size, maturity, and color, and contained more blonde peas than peas irrigated at only 1 stage of growth. A continuous source of water at low tension extended vine growth, blooming, and pod filling, and produced peas of undesirably low quality.

Water use. Soil moisture determinations through the growing season showed earlier extraction of water from the 60-120 cm soil depths by non-irrigated peas than by irrigated peas. All the available water from the upper 60 cm of soil and most or all the available water in the 60-120 cm depth was used by the non-irrigated peas each year (Table 3). In the first 2 experiments considerable available water remained at harvest time in the upper 120 cm of soil where irrigation water had been applied. The nearly uniform and complete depletion of water from the 0-120 cm depth in the last 2 experiments suggests some water extraction from below 120 cm. Unfortunately, methods used are unable to describe soil moisture changes in depths below 120 cm. Differences in water use between experiments were associated with the amount of rainfall during the growing season and length of time between planting and harvest. Evapo-transpiration increased with an increase in rainfall, an increase in the number of days from planting to harvest, and an increase in the number of irrigations applied (Tables 1 and 3).

Table 3. Water source and use during growing season.

Year and growth stage when irrigated	Water source and use during growing season			
	Rain	Soil	Irrigation	Total
	cms			
1969				
not irrigated	8.4	12.2	0.0	20.6
bl-pfi[zy]	8.4	4.0	9.3	21.7
pfi	8.4	7.0	5.4	20.8
1970				
not irrigated	7.8	17.5	0.0	25.3
pre-bl-pfl-pfi	7.8	8.8	22.0	38.5
bl-pfi[y]	7.8	10.5	13.0	31.2
1971				
not irrigated	18.5	15.8	0.0	34.3
pfi	18.5	15.8	4.5	38.8
pre-bl	18.5	15.8	8.5	42.8
pre-bl-pfi	18.5	15.8	13.0	47.3
pre-pfi	18.5	15.8	8.5	42.8
bl-pfi	18.5	15.8	8.8	43.1
1972				
not irrigated	11.5	17.5	0.0	29.0
pfi	11.5	17.5	4.5	33.5
bl	11.5	18.0	4.5	34.0
pre-bl-pfi	11.5	17.0	13.5	42.0
pre-pfi	11.5	18.0	9.0	38.5
bl-pfi	11.5	18.0	9.0	38.5

[z]Pre-prebloom, bl-blooming, pfl-pods flat, and pfi-pods filling.

[y]Soil moisture tension maintained at 0.5 atmosphere or less at 30 cm depth during the growing season by this moisture regime.

Soil moisture tensions during the growing season were maintained at 0.5 atmosphere or less at the 30 cm soil depth in each of the first 2 experiments by irrigating at blooming and again when pods were filling (Table 3). Soil moisture tensions prior to blooming exceeded 1 atmosphere at 30 cms in all irrigation treatments in each of the last 2 experiments. Vine growth and pea yields were higher in the last 2 experiments than in the first 2 experiments (Tables 1 and 2). Some factor or factors other than soil moisture tensions of these magnitudes greatly influenced plant growth and pea yields.

These results indicate that minimum moisture stress during pod filling is more critical for yield than at other stages of growth. Low moisture stress during all stages of growth results in maximum plant growth, number of pods per plant, yield, and reduction in the quality of the peas for processing. Factors which make for the establishment of a critical soil moisture tension difficult for processing peas are their short growing season, rapidly expanding root system, sensitivity to climatic conditions, and growth-quality interactions.

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