Impact of Seedborne and Current Season PVY in Shepody and Russet Norkotah

Philip B. Hamm[1], Dan C. Hane[1], Ken Rykbost[2], Ron Voss[3] and Don Kirby[4]

[1]Oregon State University, Hermiston OR, [2]Oregon State University, Klamath Falls OR, and [3]University of California, Davis California, and [4]University of California, Tule Lake CA

Introduction

Seedborne potato viruses are a chronic problem for commercial growers whether they are growing potatoes for seed, processing, or the fresh market. The introduction of cultivars which express milder symptoms to Potato Virus Y (PVY) infections than Russet Burbank has led to an assumption that the effects on yield are not significant. Two relatively new cultivars, Shepody and Russet Norkotah, express symptoms from seedborne PVY infection that are variable, but often show only a mild mosaic. Seedborne infections can also cause some stunting in Russet Norkotah, but this symptom is often absent in cv. Shepody. Current season PVY infection often is undetectable through symptom expression alone and often results in high levels of PVY infection in seed because of the difficulty seed growers have in identifying and rogueing infected plants.

Though the overall impact of PVY on potato production in the United States is not well documented, there is evidence that varietal differences exist (1,5). Information is unavailable on the effects of PVY infection in either Shepody or Russet Norkotah cvs. Compensatory yield increases have been reported for healthy plants growing adjacent to plants infected by potato leafroll virus (2,3), but results on compensatory yields with PVY infection are mixed (1,5,7).

The work reported here was undertaken to better understand the impact of PVY in cvs. Shepody and Russet Norkotah where mild symptom expression is often observed. Additional work was directed at Russet Norkotah and how environment may impact PVY effects. Experiments were conducted to: 1) compare tuber yield and quality between plants with seedborne PVY infection and plants from non-infected seed pieces, and 2) determine the benefit, if any, of compensatory yield for plants grown from virus free seed being adjacent to plants infected from seed piece inoculum.

MATERIALS AND METHODS

These experiments were conducted in 1994 and 1995 under center pivot irrigation in the Columbia Basin of Oregon, a low elevation, desert environment with a growing season of 180 or more days or in 1996 and 1997 at the low elevation site as well as at high elevation, more moderate environments, near Klamath Falls OR and Tule Lake California.

1994 & 1995

In 1994, commercial fields of cultivars Shepody and Russet Norkotah potatoes were scouted on June 1 for the occurrence of seedborne PVY infected plants. The Russet Norkotah field had been planted with seed rejected for certification (PVY virus levels exceeded the 3% allowed). Planting dates were March 22 and March 23 for the Shepody and Russet Norkotah field, respectively. Emergence for both varieties occurred about May 1. Plants in both fields were approximately 12 inch tall at the time of selection. PVY infected plants were selected only where symptom expression occurred throughout the plant and when bordered by at least three symptomless plants at both ends within the row and in the parallel bordering rows. Leaf samples were taken from the infected plant and an adjacent symptomless plant and then tested by ELISA. Comparisons were made only where a PVY infected plant was adjacent to a virus free plant, as established by ELISA. Eighteen comparisons were made for both cultivars. In-row spacing of plants was approximately 10 inches. Rows were spaced at 2.8 feet. The Norkotah field was vine killed July 7 while the Shepody vines remained green until harvest. The seedborne infected plant (PLANT 1), the adjacent plant grown from virus free seed (PLANT 2) and the third plant in sequence, also grown from virus free seed, (PLANT 3) were individually hand harvested on July 21. Total tuber weight, tuber number, and specific gravity (air/water weight) were measured for each hill. Methods in 1995 were similar to those used in 1994, with an additional plot added when comparing Shepody.

1996 & 1997

Plots were set up in 1996, and 1997, at three experiment stations, HAREC (Hermiston Agricultural Research & Extension Center, Hermiston OR) IREC (Irrigated Research & Extension Center, Tule Lake California) and KES (Klamath Experiment Station, Klamath Falls Oregon) as follows. The experimental design at each site included two-row, 60-hill plots, two border rows between plot rows planted with PVY-free seed, and five replications. Five treatments included the following blends of seed lots: 1) 60 seed pieces from the PVY-free lot (Lot #1); 2) 45 seed pieces from Lot #1 and 15 seed pieces from the PVY-infected lot (Lot #2); 3) 30 seed pieces from each lot; 4) 15 seed pieces from Lot #1 and 45 seed pieces from Lot #2; and 5) 60 seed pieces from Lot #2. Treatments were arranged in a randomized complete block design. Seed tubers were hand-cut to approximately 42 to 56 g per seed piece about 10 days prior to planting. Cut seed lots were maintained in isolation and suberized at approximately 95% relative humidity and 13 C until they were blended immediately prior to planting.

Plants in all plots were ELISA tested shortly after 100% emergence each year to verify their virus status. All healthy plants each year were again ELISA tested to determine spread of current season infection into adjacent healthy plants.

1994 & 1995 Results & Discussion

Shepody plants grown from PVY infected seed produced less total yield than plants grown from virus free seed (Table 1). Total yield was reduced by 28.7%, 41.1%, and 47.3% in plants grown from PVY infected seed (Table 1, PLANT 1) when compared to those grown from virus free seed (PLANT 3) for 1994, 1995-

A, and 1995-B trials, respectively. Likewise, seedborne infected Russet Norkotah plants produced less total yield by 45.6% and 48.8% in 1994 and 1995, respectively, than plants grown from PVY free seed (Table 2). Total yield of Shepody plants (PLANT 2) growing adjacent to seedborne infected plants did not differ from that of PLANT 3 (Table 1). In Russet Norkotah, a decrease in yield was measured for PLANT 2 when compared to PLANT 3 in 1995, both in total and marketable yields (Table 2).

Marketable yield of tubers from Shepody plants (tubers weighing more than 6 oz) was measured in 1995. When compared to PLANT 3, which originated from virus free seed, the seedborne infected plant (PLANT 1) produced 55.8% and 79.4% less marketable yield for experiments 1995-A and 1995-B, respectively (Table 1). In the 1995 Russet Norkotah trial, reduction in percent marketable yield for seedborne infected plants was 65.1% when compared to PLANT 3 (Table 2).

In the 1995-A trial, infected Shepody plants produced fewer tubers than either adjacent PLANT 2 or PLANT 3 (Table 1). Similarly, in 1995, seedborne infected Russet Norkotah plants produced fewer tubers than plants grown from virus free seed (Table 2). Average tuber weight was also reduced in both cultivars for plants grown from seedborne infection. Average tuber weight in Shepody was reduced from 6.9 oz to 5.2 oz in 1994, a loss of 24.1%. In 1995, Shepody tuber size was reduced 41.2%, going from 3 oz to 1.8 oz. In Russet Norkotah, a 30.3% reduction in average tuber weight was measured in 1994, falling from 6.5 oz to 4.6 oz.

Specific gravity in Shepody was unaffected by seedborne infections while in Russet Norkotah, specific gravity of tubers was lower for seedborne infected plants only in 1994 (Tables 1 & 2).

Most Shepody plants grown from PVY free seed (PLANT 2 & PLANT 3) became infected as the growing season progressed (Table 3). One month after the first assay, 90.6% of PLANTS 2 and 84.4% of PLANTS 3 have become infected. By mid-July, nearly all plants were infected.

The work reported here shows that degree of symptom expression is not a reliable indicator of the effects of seedborne PVY infection on tuber yield and quality. The two cultivars, Shepody and Russet Norkotah, both of which express mild symptoms to PVY infection, were found to be significantly impacted by this virus. With Shepody, reduction in marketable yield for seedborne infected plants was 15% and 30% greater than losses measured for total yield (Table 1, 1995-A and 1995-B). In Russet Norkotah, reduction in marketable yield was also greater than reduction in total yield, 65.1% verses 48.8%. Gladders and Campbell-Hill (1) also reported a higher percent yield loss for marketable tubers than for total yield with infected plants. However, their data shows only about a 4% differential for the variety Morene compared to 15% or more found in the varieties tested here.

The number of tubers per plant for these cultivars was sometimes reduced in plants infected with seedborne PVY. This agrees with other work involving seedborne infections of PVY (1,5).

The reduction in average tuber weight for both Shepody and Russet Norkotah coupled with fewer tubers per plant accounts for the greater reduction measured for marketable yield than for total yield. The lack of disparity between treatments for tuber weight for Russet Norkotah in 1995 could be associated with the hail shortened season which prevented full development of plants grown from virus free seed.

No difference was observed in specific gravity for Shepody between tubers of plants grown from infected seed and those grown from non-infected seed, but was reduced in Russet Norkotah in 1994. It is unlikely that maximum specific gravity was attained in 1995 due to interruption of growth by a hailstorm. However, since Russet Norkotah is not used for processing, a reduced specific gravity is not considered important.

Total yield of Shepody plants developing from virus free seed (PLANT 2) and growing adjacent to seedborne infected plants was never higher than that of its neighbor (PLANT 3), indicating no compensatory effect due to PLANT 2 being adjacent to the less competitive seedborne infected plant (Table 1). Likewise, no compensatory yield effects were measured for Russet Norkotah. Rather, in the 1995 experiment, the plant with a potential compensatory advantage (PLANT 2) yielded less than the plant adjacent to it (PLANT 3), which had no positional advantage. It is likely that PLANT 2 become infected early enough in the season to negatively impact its yield. These results agree with those of Gladders and Campbell-Hill (1) who found no compensatory increases in yield for the cultivar Morene from a healthy plant growing adjacent to a single plant with seedborne PVY infection.

In 1995, ELISA tests confirmed that most Shepody plants grown from virus free seed became PVY infected within 65 days of planting when adjacent to seedborne infected plants (Table 2). This would be 35-40 days after plant emergence. This rate of PVY spread to adjacent plants that were grown from virus free seed likely occurred in 1994 as well. Additionally, Russet Norkotah was impacted more by current season PVY infection than Shepody as indicated by a yield reduction for PLANT 2 compared to PLANT 3 in 1995 only for Russet Norkotah.
Due to the yield and quality losses associated with seedborne PVY infections reported here, and because of the apparent ease with which PVY can spread, at least in this environment, and the subsequent difficulties in identifying infection in these cultivars, seed growers need to increase their efforts to plant only virus free seed and rogue infected plants. Clearly, commercial production can also benefit by planting seed lots with low amounts of PVY and controlling current season spread of infection.

1996 & 1997 Results and Discussion

Seedborne PVY infection had no affect on rate of emergence or final stands in either year at KES or HAREC. Stands were 94% or higher in all treatments in both years. Emergence data were not recorded at IREC. KES data showed no affect of PVY infection level on internal defects, based on inspection of 10 large

tubers from each plot in both years. Specific gravity was unaffected by PVY infection at KES and HAREC in either year.

In both years, plants in the seed lot found to be PVY-free in greenhouse tests exhibited nearly 0% PVY in initial field samples (Table 4). The infected seed lot in 1996 had initial field infection readings of about 65% compared to a greenhouse test of 49%. The infected seed lot in 1997 had initial field infection readings of nearly 100% at each site. Plants in blended seed treatments had infection levels approximately proportional to blending ratios in initial samples in both years.

Early season canopy development appeared to be unaffected by seedborne PVY infection. Visual infection symptoms were not evident in plants at the time of early season tissue sampling at KES and IREC. Minor stunting and some leaf sheen was observed at HAREC. However, earlier senescence was observed in plots with high infection levels at KES and HAREC in both years. Poor expression of PVY symptoms in the Russet Norkotah cultivar accounts for the failure of field inspections to detect current season PVY infections in seed lots.

Greater virus spread occurred at HAREC than at either Klamath Basin site in both years (Table 4). The uninfected seed lot reached 79 and 87% PVY infection by August at HAREC in 1996 and 1997, respectively. Plants in all other treatments were nearly 100% infected by August at HAREC in both years. At KES and IREC, plants in the PVY-free lot had 21% PVY infection by late-season in 1996. In 1997, little virus spread occurred at IREC while extensive spread was observed at KES (Table 4).

At HAREC, cutting knives were disinfected between seed tubers. This was not done at KES or IREC. Isolation of seed lots during suberization until just before planting probably prevented virus transmission between seed lots for blended treatments. Initial infection levels in blended treatments at all sites in 1997 were in direct proportion to blending ratios (Table 4). Variability in initial infection levels between locations in 1996 was probably due to the natural random variability of infection in tubers from the infected seed lot and random sampling of plants.

Late-season tissue samples from treatments 4 and 5 for KES in 1996 could not be assayed due to sample deterioration (Table 4). Plants were senescing when samples were collected, and a one-day delay in shipment resulted in further sample deterioration. The increase in PVY infection in treatments 1, 2, and 3 was 20 to 25% at KES and 20 to 35% at IREC, in contrast to much greater spread observed at HAREC. In 1997, PVY spread was greatest at HAREC and least at IREC.

The high infection levels observed at HAREC in plots initially PVY-free, and surrounded on both sides by two border rows planted with PVY-free seed, suggest a major role for insect vectored transmission of PVY. Greater virus spread at HAREC may be explained by climatic differences between sites. Much warmer

temperatures at HAREC than at Klamath Basin sites favored greater insect populations. Early-season aphid flights are common in the Columbia Basin, while aphid populations are low and occur much later in the season in the Klamath Basin. Frequent windy conditions in the Columbia Basin also enhance the opportunity for plant-to-plant mechanical transmission.

In both years, total U.S. No.1 yields were significantly lower for the infected seed lot than for the PVY-free lot at HAREC (Tables 5 and 6). Yields were intermediate for blended seed lot treatments. Reductions in No.1 yields between treatment 1 (all seed from PVY-free lot) and treatment 5 (all seed from infected lot) were 40 and 37% in 1996 and 1997, respectively, even though plants in treatment 1 were highly infected with PVY by late-season.

Effects of seedborne PVY infection on yields were less severe at IREC and KES than at HAREC (Tables 5 and 6). U.S. No.1 yield reductions between treatments 1 and 5 were 20% in both years at IREC. Reductions of 7 and 16% at KES in 1996 and 1997, respectively, were not significant. PVY infection levels did not affect yield of tubers at IREC or KES, or U.S. No.2s and culls at any location. Therefore, effects of PVY infection on total yield were nearly the same as effects on total No.1 yield (Tables 5 and 6). Different seed lots can produce minor to large differences in yield for reasons unrelated to disease infections. The lack of yield variability between treatments 1 through 3 at KES in 1996 (Table 5) and treatments 2 through 4 at IREC in 1997 (Table 6) suggests yield differences in this study were not merely due to seed lot differences.

Regression analyses for relationships of total and total No.1 yields to initial PVY infection levels were evaluated for each site. In both years, regression analyses found significant differences in the slope of equations among locations, indicating a greater effect of PVY infection at HAREC, less at IREC, and the least effect at KES. An over-years analysis found significant differences between years in yield level, but not in the slope of the regression equations, indicating consistent effects of seedborne PVY on yields from year to year within a given location.

Greater effects of virus infection on yield loss at HAREC than at IREC and KES are probably due to climatic differences between sites. HAREC is situated at <1476 foot elevation, has a 180-day growing season, frequently experiences maximum air temperatures in excess of 100 F, and is often subjected to high wind velocities. These conditions produce significant environmental stress for potato plants, particularly plants more vulnerable due to disease infections. In contrast, Klamath Basin sites are at 4101 foot elevation, seldom experience maximum air temperatures above 86 F, seldom exceed 90 frost-free days, and are exposed to much less wind during summer months than the Columbia Basin.

Acknowledgments
Financial support of this research was provided by the Oregon Agricultural Experiment Station, the Oregon Potato Commission, and the Klamath Basin and Blue Mountain Potato Growers Associations. Laboratory analyses of plant tissue samples were performed by Ms. Joy Jaeger.

Literature Cited (1994 & 1995)

1. Gladders, P. and C.E. Campbell-Hill. 1988. Effect of potato virus Y on the yield of potato cultivar Morene. Tests of Agricultural Chemicals and Cultivars, 9:90-91.

2. Harper, F.R., G.A. Nelson, and U.J. Pittman. 1975. Relationship between leaf roll symptoms and yield of Netted Gem potato. Phytopathology 65:1242-1244.

3. Kirkpatrick, H.C., and F.M. Blodgett. 1943. Yield losses caused by leaf roll of potatoes. Am. Potato J. 20:53-56.

4. Kuel, R.O. 1994. Statistical principles of research design and analysis. Chapter 15. Duxbury Press, Belmont, California

5. Kurppa, A., and A. Hassi 1989 Reaction of four table potato cultivars to primary and secondary infection by potato virus Y^O and Y^N. Ann. Agri. Fenn 28:297-307.

6. SAS Institute Inc. 1988. SAS/STAT User's Guide. Release 6.03 Edition SAS Institute Inc., Cary, NC.

7. Wooster, P. 1988. Tolerance to potato virus Y^O. Environmental Aspects of Appl. Biol. 19-20th September. 17, pt 1-2, pp. 103-107.

Literature Cited (1996 & 1997)

1. Bonde, R., E.S. Schultz and W.P. Raleigh. 1943. Rate of spread and effect on yield of potato virus diseases. Maine Agric. Stat. Bull. 421, 28pp.

2. Clark, M.F. and A.N. Adams 1977 Characteristics of the microplate method of enzyme-linked immunosorbent assay for detection of plant viruses. J. Gen Virol. 34:475-484.

3. Mondjana, A.M., D.I. Rouse, and T.L. German. 1993. The impact of PVY on potato yield and severity of early dying. Am. Potato J. 70:829 (abstract).

Table 1. The effect of seedborne PVY infection on yield, tuber numbers, average tuber size, and specific gravity in Shepody potatoes.

Plant Virus Status[1]	Yield				Tubers/Plant	Average Tuber Weight	Specific Gravity
	.... Total		.... >3 oz				
1994:	oz plant	% change[3]	Oz Plant	% change		oz	
PLANT 1	41.8a[4]	-28.7	--[5]	--[5]	8.2a	5.2a	1.072a
PLANT 2	53.5ab	nc[6]	--	--	7.4a	7.3b	1.076a
PLANT 3	58.6b	....	--	--	8.9a	6.9b	1.074a
1995-A:[2]							
PLANT 1	15.8a	-41.1	8.0a	-55.8	6.4a	2.6a	1.063a
PLANT 2	25.0b	nc	14.1b	nc	8.6b	3.0a	1.066a
PLANT 3	26.8b	....	18.2b	....	8.6b	3.3a	1.065a
1995-B:							
PLANT 1	12.3a	-47.3	3.1a	-79.4	7.3a	1.8a	1.064a
PLANT 2	25.6b	nc	14.4b	nc	10.9b	2.6b	1.066a
PLANT 3	23.2b	....	15.3b	....	8.6ab	3.0b	1.063a

[1] PLANT 1 = Plant originating from PVY infected seed; PLANT 2 = plant adjacent to PLANT 1 and originating from PVY free seed; PLANT 3 = adjacent to Plant 2 and originating from PVY free seed.

[2] Experiment year, -A and -B denote different seed sources.

[3] ((PLANT 3-PLANT 1)/PLANT 3)*100

[4] Within year and seed source, numbers in columns followed by the same letter are not significantly different at P=0.05.

[5] --, Not recorded in 1994.

[6] nc = no change

Table 2. The effect of seedborne PVY infection on yield, tuber numbers, average tuber size, and specific gravity in Russet Norkotah potatoes.

Plant Virus Status[1]	Yield				Tubers/Plant	Average Tuber Weight	Specific Gravity
	.... Total		.... 3 oz				
1994[2]:	Oz/plant	% change[3]	Oz/plant	% change		oz	
PLANT 1	37.3a[4]	-45.5	--[5]	--[6]	8.2a	4.6a	1.070a
PLANT 2	58.1b	nc[6]	–	–	9.7a	6.6b	1.077b
PLANT 3	68.5b	....	--	--	11.6a	6.5b	1.076b
1995:							
PLANT 1	15.5a	-48.8	6.6a	-65.1	6.1a	2.6a	1.067a
PLANT 2	23.7b	-21.4	11.0a	-41.8	10.1b	2.6a	1.070a
PLANT 3	30.2c	....	18.9b	....	10.5b	3.2a	1.070a

[1] PLANT 1 = Plant originating from PVY infected seed; PLANT 2 = plant adjacent to PLANT 1 and originating from PVY free seed; PLANT 3 = adjacent to Plant 2 and originating from PVY free seed.

[2] Experiment year.

[3] ((PLANT 3-PLANT 1)/PLANT 3)*100

[4] Within year, numbers in columns followed by the same letter are not significantly different at P=0.05.

[5] --, Not recorded in 1994.

[6] nc = no change

Table 3. Number and percent of Shepody plants positive for PVY by ELISA testing at three dates, Hermiston, OR, 1995.

	.... Plant Virus Status[1]		
Test Date	PLANT 1	PLANT 2	PLANT 3
	no.(percent) positive plants		
5/24	32(100)	0(0)	0(0)
6/20	--[2]	29(90.6)	27(84.4)
7/18	--	31(96.9)	28(87.5)

[1] PLANT 1 = Plant originating from PVY infected seed; PLANT 2 = plant adjacent to PLANT 1 and originating from PVY free seed; PLANT 3 = adjacent to Plant 2 and originating from PVY free seed.

[2] --, Not re-tested, all were PVY positive on 5/24.

Table 4. PVY infection levels for Russet Norkotah seed lot treatments grown at three locations in 1996 and 1997.

	PVY Infection Level				
	1996		1997		
Treatment	Early season	Late season	Early season	Mid Season	Late season
		%			
		HAREC			
1	0	79	2	26	87
2	20	97	27	58	98
3	38	98	50	85	100
4	53	100	73	92	100
5	60	99	98	99	100
		IREC			
1	3	21	1	2	7
2	16	52	24	23	34
3	30	67	48	42	56
4	62	81	74	*	72
5	56	85	99	*	100
		KES			
1	1	21	0	14	45
2	21	45	23	45	59
3	39	65	51	69	80
4	51	*	73	*	93
5	79	*	97	*	100
		MEAN			
1	1	40	1	14	46
2	19	65	25	42	64
3	36	77	50	65	79
4	55	*	73	*	88
5	65	*	98	*	100

* No data collected

Table 5. Yield, grade, and tuber size distribution response to seedborne PVY infection in Russet Norkotah potatoes grown at three locations in 1996.

Treatment	Initial PVY (%)	Yield U.S. No. 1s 4-8 oz	8-12 oz	>12 oz	Total	Yield <4 oz	No. 2s & Culls	Total
				Tons/Ac				
				HAREC				
1	0	7.1	8.3	6.2	21.7	3.2	0.6	25.4
2	20	6.8	6.4	5.1	18.4	3.8	0.5	22.7
3	38	5.8	6.1	4.3	16.2	3.4	0.4	20.0
4	53	6.3	5.3	4.5	16.1	3.5	0.4	20.0
5	60	4.7	4.2	3.9	12.8	3.3	0.4	16.4
LSD (0.05)		1.3	1.3	1.2	2.5	NS	NS	2.8
CV (%)		15	17	18	11	12	77	10
				IREC				
1	3	5.0	7.2	8.6	20.8	2.4	2.6	25.9
2	16	5.7	6.7	7.4	19.7	2.2	1.7	23.7
3	30	4.7	6.7	7.1	18.4	2.4	1.4	22.2
4	62	5.4	7.5	6.3	19.1	2.0	1.3	22.3
5	56	5.6	5.9	5.3	16.7	2.4	2.0	21.0
LSD (0.05)		NS	NS	1.6	2.5	NS	NS	2.2
CV(%)		12	16	17	10	17	51	7
				KES				
1	1	6.1	5.6	7.7	19.3	1.7	2.0	23.1
2	21	6.4	6.3	7.5	20.1	1.5	2.3	23.9
3	39	6.3	6.6	6.7	19.7	1.5	2.5	23.7
4	51	5.9	6.1	6.7	18.8	1.3	1.7	21.8
5	79	5.9	6.1	6.1	18.0	1.3	1.5	20.8
LSD (0.05)		NS	NS	NS	NS	NS	NS	NS
CV (%)		22	16	24	11	25	29	10

Table 6. Yield, grade, and tuber size distribution response to seedborne PVY infection in Russet Norkotah potatoes grown at three locations in 1997.

Treatment	Initial PVY (%)	Yield U.S. No. 1s 4-8 oz	8-12 oz	>12 oz	Total	Yield <4 oz	No. 2s & Culls	Total
				Tons/Ac				
				HAREC				
1	2	13.3	9.0	2.9	25.1	4.9	0.5	30.5
2	27	11.1	7.0	2.4	20.5	4.8	0.3	25.6
3	50	10.0	6.2	1.6	17.8	5.4	0.3	23.5
4	73	9.4	5.1	1.8	16.3	4.3	0.4	21.1
5	98	8.3	5.8	1.6	15.8	3.8	0.7	20.1
LSD (0.05)	8	1.7	1.7	NS	2.8	1.0	NS	2.4
CV (%)	12	12	19	41	11	16	65	7
				IREC				
1	1	7.9	8.0	3.1	19.1	1.7	0.7	21.5
2	24	7.1	6.4	4.0	17.5	1.4	0.6	19.5
3	48	7.8	6.1	2.8	16.7	1.6	0.5	18.8
4	74	7.2	6.1	3.2	16.6	1.6	0.5	18.6
5	99	8.4	5.5	1.4	15.4	1.4	0.5	17.3
LSD (0.05)	9	NS	1.4	1.2	1.1	NS	NS	0.9
CV(%)	13	14	16	31	5	24	41	3
				KES				
1	0	6.7	9.5	10.0	26.2	1.3	2.2	29.6
2	23	7.2	9.9	9.2	26.3	1.2	1.5	29.0
3	51	5.8	8.0	9.9	23.8	1.0	2.0	26.7
4	73	6.1	7.8	9.3	23.2	1.2	1.3	25.7
5	97	5.6	7.9	8.6	22.1	0.9	1.6	24.5
LSD (0.05)	6	NS	1.7	NS	NS	NS	NS	2.8
CV (%)	9	18	15	20	10	30	40	8