AN EVALUATION OF MECHANICALLY APPLIED STRAW MULCH ON FURROW IRRIGATED ONIONS

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Introduction

The potential of mechanically applied straw mulch to reduce nutrient, pesticide and sediment losses from furrow irrigated onions and increase water use efficiency was evaluated on a Nyssa silt loam with three percent slope. Nitrogen and phosphorus losses in the runoff were of particular interest, both because of their economic importance as farm inputs and their roles as environmental contaminants. Measured losses of phosphorus included phosphate-P dissolved in runoff water, phosphate-P present in the sediment, and total P in the sediment. Measured nitrogen losses included ammonium and nitrate in runoff and on the sediment and total reduced N in the sediment.

Methods

Dai Maru onions were planted in 22-inch rows in Nyssa silt loam with 3 percent slope that had received 0, 100, or 400 lb phosphate/acre in the form of triple superphosphate. Treatments consisted of complete factorial of two wheat straw mulch rates (0 and 800 lb/acre) and three rates of applied phosphate. Straw mulch was applied to the bottom of irrigation furrows (furrow-mulching) using a Hobson Mechanical Straw Mulch Applicator. The site was located at the Malheur Experiment Station, OSU, Ontario, Oregon and followed exactly on top of identical phosphate and mechanical straw mulch treatments for potatoes in 1990. The top foot of surface soil contained 10.4 mg/g nitrate-N and 3.9 mg/g ammonium-N. Onions were sidedressed with 180 lb N/acre as sulfur coated urea.

Forty five percent of the straw was applied to the furrow bottoms prior to the first irrigation and 55 percent of the straw was applied after cultivations prior to the fifth irrigation. Onions were thinned to one plant for every 2.5 inches of row. Irrigation furrows were 235 feet long and all furrows of all plots received 17 irrigations during the season, with water inflow in each furrow set at 2 gallons/minute. Irrigation duration in furrows with and without mulch was identical. Weeds and insects were controlled using normal commercial onion production practices. All irrigation furrows were front wheel tracks of a John Deere 2040 tractor.

Water and Sediment Measurement

Onset of inflow, outflow, and hourly measurements of inflow, outflow, and sediment yield were recorded. For each water outflow rate reading, a one liter sample was placed in an Imhoff cone and allowed to settle for 15 minutes. Sediment content in the water, y in g/l, was found to be related to the Imhoff cone reading after 15 minutes (x) by the equation

$y = 1.015x$

$r^2 = 0.98$

$p < 0.0001$.

Composite water samples were collected in 5 gallon buckets to obtain sediment samples for nutrient analysis during the first six irrigations. Sediment was analyzed for nitrate-N, ammonium-N, total N, phosphate-P, and total P.

Total inflow, outflow, infiltration, and sediment loss were integrated from hourly measurements using LOTUS 1-2-3 software program Infilcal 4.0 (Shock and Shock).

During six irrigations, hourly inflow water samples and hourly outflow water samples were collected from every plot. The collection time of the water was recorded and composite water samples were made in proportion to the sample represented in the water inflow or outflow using InfilCal 4.0 (Shock and Shock). Composite water samples were analyzed for nitrate-N, ammonium-N, and phosphate-P.

Net nutrient losses were calculated by comparing the nutrient content in inflow water with the nutrient content in the outflow plus sediment. Average nutrient concentrations from the six monitored irrigations were used to estimate the nutrient concentrations in the eleven irrigations where no water or sediment samples were collected for analyses.

Results and Discussion

During the first irrigation, greater lateral movement of water was visually evident into the onion beds. Splitting the application of straw mulch allowed cultivation for weed control. Pronounced differences in sediment yield continued throughout the season as evidenced by Imhoff cones with runoff and sediment from mulched and non-mulched furrows during the eighth irrigation. Mechanical furrow mulching decreased runoff, increased infiltration, increased irrigation efficiency, and decreased sediment yield (Table 1). Water infiltration in the drier plots without mulch exceeded the crop's evapotranspiration water requirement.

Applied phosphate sensitively increased onion yields in both mulched and non-mulched plots (Table 2). All of the yield increase due to phosphate occurred in the largest and most desirable market size bulbs.

Furrow mulching increased onion yield, onion market grade, and gross economic return (Table 3). Lower economic responses would be expected on a less erodible site.

Sediment, phosphorus, and nitrogen losses were particularly large for onions grown on this site. Sediment and nutrient losses may be very high without furrow-mulching because the onion plant presents little in the way of roots or leaves to interfere with erosive processes.

Straw mulch reduced the losses of dissolved and soluble phosphate-P from 17.3 to 2.5 lb phosphate per acre (Figure 4) and insoluble-P lost in the sediment from 313 to 15.4 lb phosphorus per acre.

Losses of nitrate-N, ammonium-N, and organic-N were similarly reduced by furrow mulching (Figures 5 and 6).

Conclusions

1. Large losses of sediment, nitrogen, and phosphorus occurred with the production of onion under furrow irrigation on a three percent slope.

2. Splitting the application of straw mulch allowed cultivation for weed control.

3. Mechanically applied straw mulch at 800 lb/acre decreased sediment yield, nitrogen losses, and phosphorus losses by 94.6, 88.8, and 94.6 percent respectively.

4. Onion yield, market grade, and gross economic return increased both with straw mulch and triple superphosphate.

5. Most of the phosphorus lost was in the form of insoluble phosphorus in the sediment. Most of the nitrogen lost was in the form of soil organic material in the sediment.

6. Furrows with straw mulch had net accumulation (not a net loss) of soluble forms of phosphate, nitrate, and ammonium while furrows without straw mulch suffered net losses of soluble nutrients.

Figure 1. Cumulative sediment loss from furrow irrigated onion grown on a Nyssa silt loam (3% slope) with strawed and non-strawed furrows. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1991.

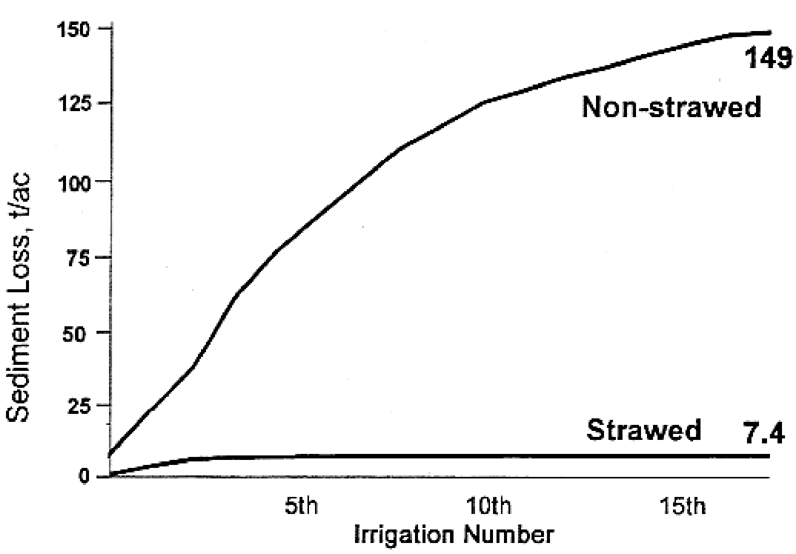

Figure 2. Cumultive phosphorus loss from furrow irrigated onions grown on a Nyssa silt loam (3% slope) with strawed or non-strawed furrows. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1991.

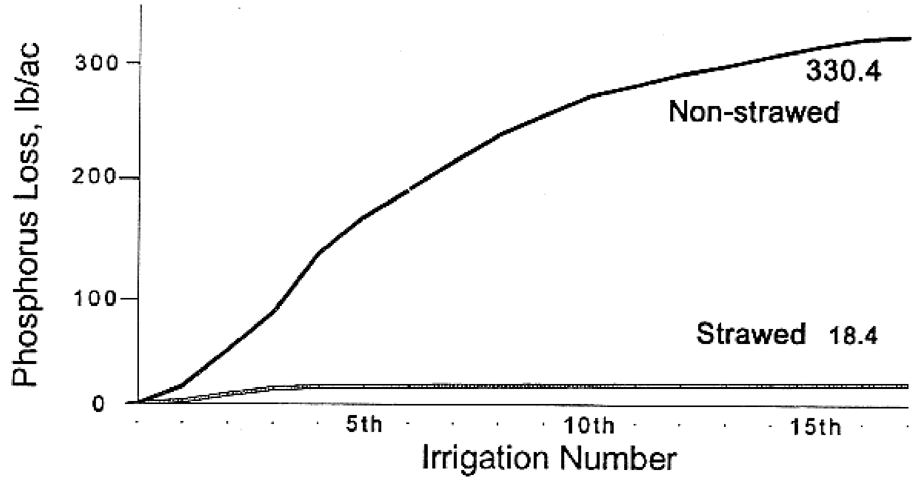

Figure 3. Cumultive nitrogen loss from furrow irrigated onions grown on a Nyssa silt loam (3% slope) with strawed or non-strawed furrows. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1991.

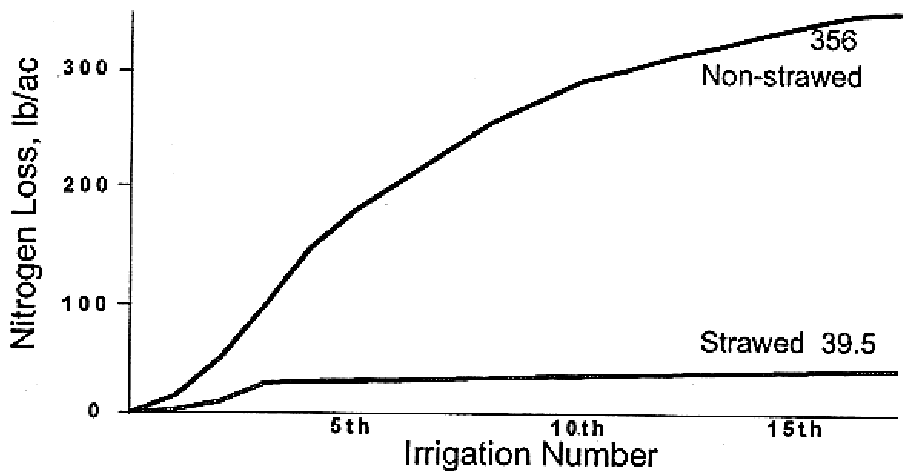

Figure 4. Partitioning of phosphorus lossed from non-strawed and strawed furrows into phosphate-P dissolved in the outflow water and soluble-P and insoluble-P in the sediment. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1991.

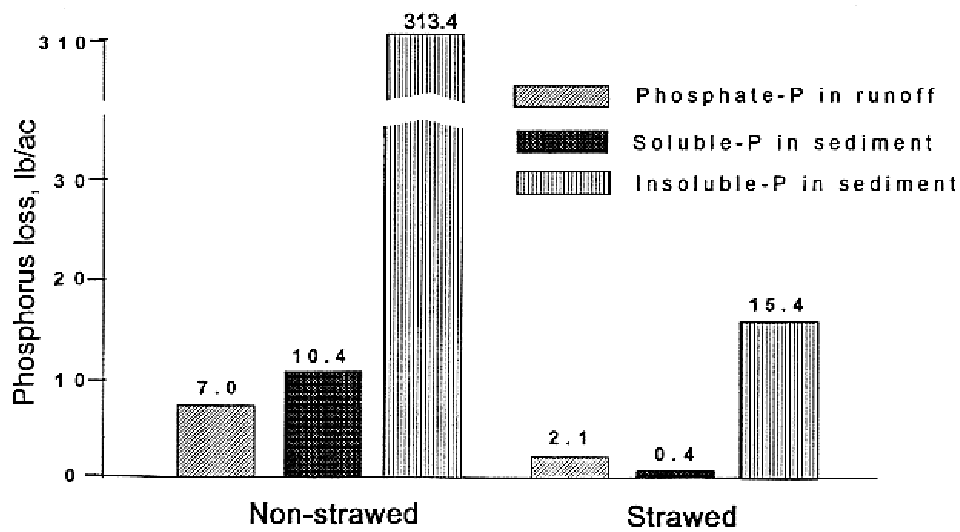

Figure 5. Partitioning of nitrogen losses from non-strawed furrows into ammonium-N and nitrate-N in the runoff water and ammonium-N, nitrate, and organic-N in the sediment. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1991.

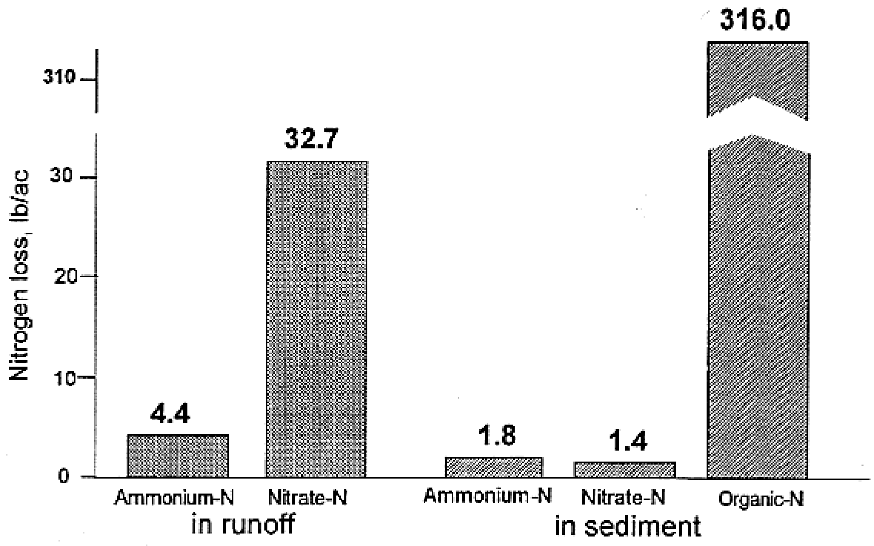

Figure 6. Partitioning of nitrogen losses from strawed furrows into ammonium-N and nitrate-N in the runoff water and ammonium-N, nitrate, and organic-N in the sediment. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1991.

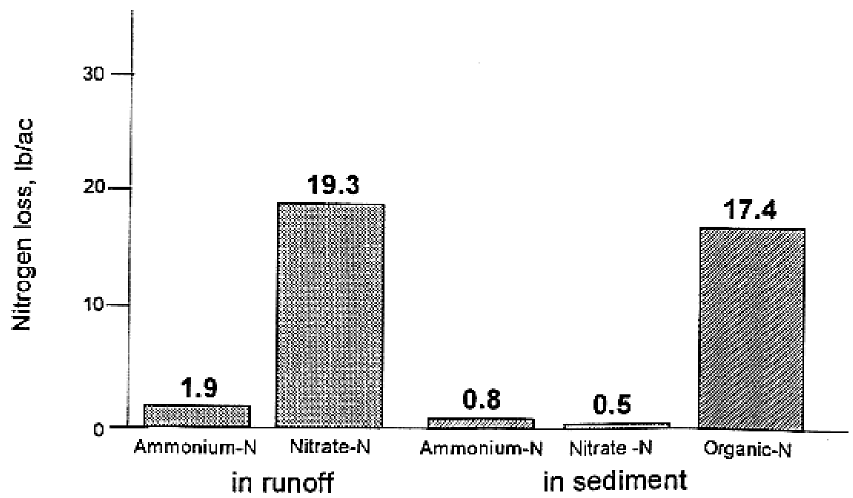

Table 1. Total irrigation, runoff, irrigation efficiency, infiltration, and sediment yield for a Nyssa silt loam with three percent slope planted to onions. Malheur Experiment Station, Oregon State University, Ontario, OR, 1991.

	Furrow mulching		
	None	Strawed	LSD(0.05)
Water applied, ac-ft/ac	8.3	8.2	ns
Water runoff, ac-ft/ac	6.2	3.6	5.1
Irrigation efficiency, %	24.9	57	5.1
Water infiltration, ac-ft/ac	2.1	4.7	6.4
Sediment lost, tons/ac	148.7	7.4	8.1

Table 2. Market grade and total yield of onions grown at three phosphorus levels with and without furrow mulching. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1991.

Treatment		Yield by market grade					
Furrow Mulching	Applied P Kg/ha	Small	Medium	Jumbo < 4"	Colossal	(All Jumbo)	Total
		---------------- Mg/ha -----------------					
None	0	3.5	25.9	9.3	0.8	-10.1	39.5

	49	2.7	22.9	12.3	0.6	-12.9	38.5
	196	2.4	24.5	19.4	1.9	-21.3	48.2
	AV	2.9	24.4	13.7	1.1	-14.8	42.1
Strawed	0	1.7	25.3	31.9	3.8	-35.7	62.7
	49	1.4	19.4	37.8	8.2	-46	66.8
	196	1	15.3	46	15.1	-61.1	77.4
	AV	1.4	20	38.6	9	-47.6	69
LSD(0.05) Mul.		0.5	ns	4.4	2.1	-5.5	6.6
LSD(0.05) P level		0.6	ns	5.3	2.5	-6.7	9.1
LSD(0.05) M x P		ns	ns	ns	3.6	(ns)	ns

Table 3. Market grade, total yield, and gross economic return of onions grown with and without furrow mulching. Oregon State University, Malheur Experiment Station, Ontario, Oregon, 1991.

		Non-strawed		Strawed		
Market class	Bulb diameter	Yield	Gross revenue	Yield	Gross revenue	LSD (0.05)
		cwt/ac	$/ac	cwt/ac	$/ac	cwt/ac
Small	[2¼"	25.8	0	12.3	0	4.7
Medium	2 ¼ to 3"	218.2	218	178.5	179	ns
Jumbo	3 to 4"	121.9	488	344.2	1,277	38.9
Colossal	m 4"	9.7	39	80.8	323	18.5
(Jumbo & Colossal)	(m 3")	-131.6		-425		-49.2
Cull disposal			-39		-67	
Total		365.9	706	615.8	1,812	66.3

Table 4. Accounting of phosphate-P, nitrate-N and ammonium-N accumulations and losses in the water under furrow-mulched onions.

	Irrigation water applied	Average nutrient concentration in irrigation water	Estimated nutrients applied in irrigation water	Average nutrient concentration in runoff water	Lost in runoff water plus sediment	Net Loss or accumulation
	ac-ft/ac	ppm	lb/ac	ppm	kg/ha	lb/ac
Non-strawed furrows						
Phosphate-P	8.3	0.15	3.3	0.43	17.3	14 Loss
Ammonium-N	8.3	0.24	5.4	0.27	6.2	0.8 Loss
Nitrate-N	8.3	1.78	39.9	1.67	34.1	5.8 Loss
Strawed furrows						
Phosphate-P	8.2	0.15	3.3	0.22	2.5	0.8 Acc
Ammonium-N	8.2	0.24	5.4	0.2	2.7	2.7 Acc
Nitrate-N	8.2	1.78	39.9	1.51	19.8	20.1 Acc