Tips on Injecting Polyacrylamide (PAM) into Sprinkler Systems to Reduce Sediment and Nutrient Losses

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We have demonstrated that polyacrylamide polymer (PAM), injected at low concentrations (5 ppm) in sprinkler water minimizes losses of sediments, phosphorus and nitrogen in tail water run-off from row crop fields on the Central Coast (Table 1). On fields where run-off is significant, the use of PAM can make both environmental and economic sense. By reducing up to 90% of the sediment losses from vegetable fields, costs of cleaning drainage ditches and sediment basins can be reduced, and water quality can be dramatically improved.

The low concentration needed to control sediment minimizes the costs of using PAM. At a 5 ppm concentration, costs of product are estimated to be between 4 and 7 dollars per acre for each inch of applied water. In addition, cost-sharing of up to 50% is possible through the USDA-NRCS. Using low concentrations of PAM is also necessary to avoid increasing the amount of run-off. We found that PAM applied at concentrations above 10 ppm could reduce infiltration into the soil, thereby increasing run-off. On many soil types, concentrations of PAM as low as a 2.5 ppm in the irrigation water may reduce sediment and nutrient loss by more than 50%.

By injecting PAM at the time that run-off begins rather than during the entire irrigation set, the amount of applied product (lbs/acre) can also be minimized. Some fields do not produce significant run-off until an hour or more after irrigation begins, especially if the soil profile is not yet saturated. Applying PAM for the first 30 minutes of an irrigation set so that some product is on the soil surface and then resuming injection of PAM when run-off begins may reduce the use of product by 30% to 50%.

We found that applying PAM before irrigating, such as by spraying it on the surface of the soil, or only injecting it at the beginning of the irrigation offers much less control of sediment loss than applying the product continuously during the irrigation. High rates of polymer are also needed (3 to 10 lb/acre) if the application occurs before irrigating rather than during. While some residual control is obtained from previous applications of PAM, in most cases, PAM must be applied with every irrigation to maximize control of sediment and nutrient losses in run-off.

Although PAM can substantially improve water quality, the polymer can be difficult to inject into irrigation systems. Because PAM is a large molecule, it is difficult to mix into water. Though it is water soluble, PAM tends to stick to itself, rather than dissolving into water. Mixing up a batch of PAM solution in a tank can be time consuming and therefore costly.

We found that for pressurized irrigation systems, direct injection of emulsified formulations of the product can be the easiest and cheapest method of application. However, only certain types of injectors can be used with PAM because of its sticky nature. PAM clogs injection pumps with valves, such as some diaphragm pumps. Centrifugal, peristaltic, and auger type pumps will often work well with PAM. Venturi injectors also can be used for injecting PAM into pressurized irrigation systems. The low injection rate required to achieve the 5 ppm and lower concentrations also limits which pumps can be used with PAM. Centrifugal pumps usually have too high of a flow rate to be used for PAM injection. Table 2 lists injection rates required for a range of system flow rates to achieve a 5 ppm concentration in the irrigation water. Figures 1 and 2 show configurations for using venturi injectors with PAM.   Venturi injectors require a pressure differential between the inflow and outflow to create suction. The pressure differential can be created by a booster pump (Figure 1) or by using a centrifugal pump to raise the pressure on the upstream side of the venturi.

A static mixer placed down stream of the injection site is recommended to pre-mix the PAM prior to injection into the main line. Static mixers, which are sections of pipe with baffles to create a mixing vortex in the flowing water, cause additional losses in pressure and should not be placed directly on the main line if possible.   The placement of an injection pump near the well pump is shown in Figure 3. We found that satisfactory mixing of emulsified PAM product can be achieved in the irrigation water without a static mixer if the distance traveled between the injection point and the field is more than 500 feet. Inject pumps may need to be configured with a static mixer as shown for the venturi in Figures 1 or 2 if the distance of mixing in the mainline is limited.

Summary

PAM can dramatically reduce sediment and nutrient loss from agricultural fields on the Central Coast; however, PAM can be challenging to use because low concentrations are needed continuously in the irrigation water when run-off is occurring. Injection rates are often very low, (1-3 ounces per minute) which limits which types of injection systems can be used. Furthermore, PAM is difficult to mix into water due to its chemical and physical properties, and it can clog injection pumps.   Fortunately, there are injection systems that are well suited for injecting emulsified PAM product which are relatively simple to use.

Table 1. Effect of Polyacrylamide (PAM) on concentration of nutrients, sediment and turbidity in run-off from Central Coast fields irrigated with solid-set impact sprinklers. Results are from non-replicated split-field trials.

Treatment	Total N	NO3-N	P (Total)	P (Soluble)	Total Suspended Solids	Turbidity
	------------------------ ppm --------------------------					NTU
	-----------------Watsonville (clay loam) ----------------					
PAM (5 ppm)	0.8	58.6	1.2	1.2	47	33
Control	2.9	48.4	2.0	0.9	652	1289
	-------------------Salinas (sandy loam) -----------------					
PAM (5ppm)	1.4	1.7	0.7	0.7	72	63
Control	4.2	1.7	1.9	0.7	985	2291
	----------------Salinas (sandy loam) --------------------					
PAM (10 ppm)	2.7	1.3	0.4	0.2	179	108
Control	5.5	1.8	2.4	0.5	1332	3536
	------------------Chualar (loamy sand) -------------------					
Pam (5 ppm)	2.3	2.7	1.9	0.8	646	218
Control	11.8	6.5	8.2	2.1	3870	503
	----------------- Santa Maria ----------------------------					
Pam (5 ppm)	1.6	14.78	0.6	0.51	60	13
Control	7.0	17.02	10.1	0.95	5930	4417
	---------------------- Gilroy (silt loam) ---------------------					
Pam (4 ppm)	1.2	8.1	1.0	0.9	74	42
Control	4.0	6.5	3.5	1.2	2057	2408

Table 2. PAM injection rates for achieving a 5 ppm concentration of active ingredient in the irrigation water for varying system flow rates or varying number of sprinkler heads.

Irrigation System Flow rate	Impact Sprinkler Nozzle Size[x] 7/64"	1/8"	PAM Injection Rate[y] 37% w/v [z]	50% w/v
gallons/minute	# of sprinkler heads		ounces/minute	
200	82	63	0.35	0.26
400	163	125	0.69	0.51
600	245	188	1.04	0.77
800	327	250	1.38	1.02
1000	408	313	1.73	1.28
1200	490	375	2.07	1.53
1400	571	438	2.42	1.79
1600	653	500	2.76	2.04
1800	735	563	3.11	2.30
2000	816	625	3.45	2.56

x. assumes 50 psi at the nozzle and a discharge rate of 2.45 and 3.2 gal/min for 7/64" and 1/8" diameter nozzles, respectively.
y. Injection rate to achieve a 5 ppm concentrationi in the irrigaiton water
z. weigh per volume concentration of PAM active ingredient in emulsified product

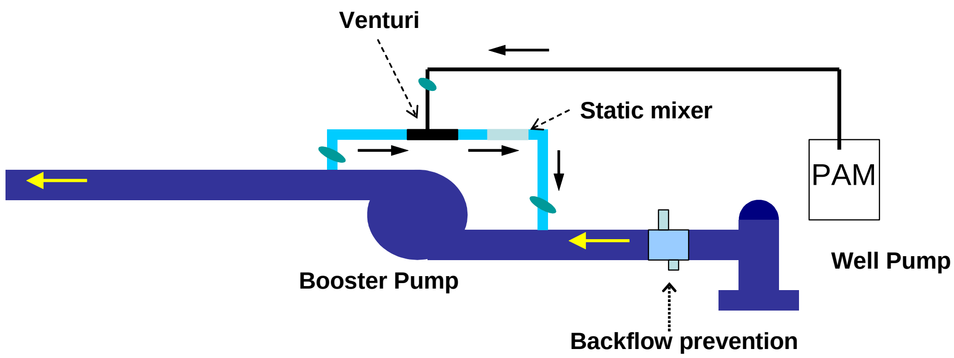

Figure 1. PAM injection using venturi injector between booster and well pump.

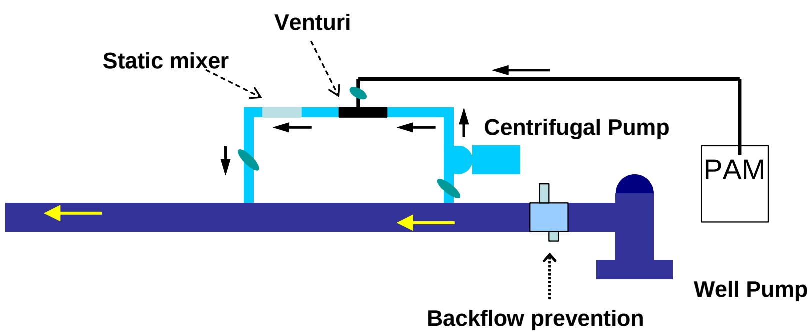

Figure 2. PAM injection using venturi injector and centrifugal pump.

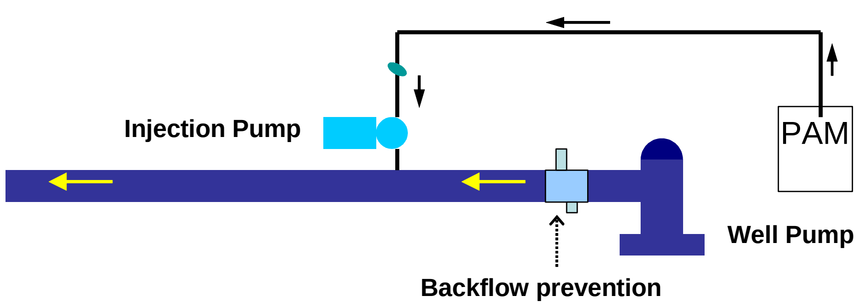

Figure 3. PAM injection using an injection pump.