Potassium Nitrate as a superior K Source for California Almonds

Almonds are a highly valuable and profitable crop for Californian farmers. However, it is not easy to maintain high yielding crops that bring in premium, high quality harvests and steady pricing. One of the farmers' major challenges is proper nutrition, especially the critical nutrient of Potassium (K). In addition, growers are faced with shortages of water, government imposed restrictions to prevent nitrogen waste, and increasing salinity levels in both water and soil. Choosing the proper K fertiliser source that maximises water and nutrient use efficiency, minimizes salinity build-up, and yet continues to enhance both yield and quality is vital. In a recent trial, the use of potassium nitrate in the fertigation clearly demonstrated to have a benefit for the grower, combined with Fan jet irrigation.

This trial in California - coordinated by UC Davis - took place over a period of 4 years, 2011-2014. The project was sponsored by PNA, aiming to find a solution for the challenges faced by almond growers, by considering the 4 R's of fertilisation practice. As a first variable, the yield response to four K-sources was compared: Potassium sulphate (SOP), potassium thiosulphate (PTS), potassium chloride (KCl), and potassium nitrate (KN). The relative amounts of two nitrogen sources were varied as well: UAN (Total nitrogen (N) - 32%: ammonium N ($N\text{-}NH_4$) – 8%, nitrate N ($N\text{-}NO_3$) - 8%, ureic nitrogen ($N - NH_2$) - 16%) and KN (KNO_3, as a source of nitrate as well as potassium) (Table 1). To achieve ideal nutrient uptake and plant response, it is critical that nutrients provided through fertigation remain in the root zone with minimum loss to the deeper soil layers. To provide growers with guidance on optimal application, two irrigation methods and two nutrient application schedules were also included in the trial. The effect of application method was investigated by comparing all eight nutrient programmes when applied by either Fan jet microsprinkler or drip irrigation. Additionally, the effect of fertigation frequency was investigated by application of nutrients in 4 dedicated fertigation events (in February, April, June and early post harvest) or in each of the 22 irrigation events. The total amount of fertilizers supplied was the same for both application frequencies and this amount was divided over the fertigation moments in such a way that the crop received 20% in Feb/Mrch, 30% in April/May, 30% in June/July and 20% early post-harvest (Aug/Sept).

K-sources

Almond kernel yield was mainly influenced by the source of K fertilisation (Figure 1). Significant yield differences between treatments were observed with trees under Fan jet irrigation. Superior yield resulted from providing a portion of the annual K requirement as fertigated potassium nitrate. Treatment (Trt) 5, a combination of banded SOP and fertigated potassium nitrate - 224 kg/ha total K- resulted in the highest increase in yield when the treatments were applied with each irrigation in 22 events by Fan jet sprinklers. The yield was increased 22% over Trt 2 (the farmer's practice check with banded SOP and fertigated PTS) and 18% over Trt 4 (only SOP). All treatments comprising potassium nitrate (3, 5, 6, 7 and 8) always numerically outperformed farmer's practice (Trt 2) and the SOP only treatment (Trt 4). The primary effect of potassium nitrate was to increase the total number of nuts, rather than increasing average nut size.

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Table 1. Potassium (K) and Nitrogen (N) supplied in the eight treatments during the trial period. Freq: Fertigation frequency (number of events), C: Continuous fertigation, P: Pulse fertigation.

		K Sources (Kg elemental K/ha)						N Sources (Kg N/ha)		
Trt	Freq	Total K	SOP Band	SOP Fert*	PTS	KCL	KNO_3	Total N	KNO_3	UAN
1 No K	P (4)	**0**						**336**		336
2 Growers Practice	P (4)	**224**	140		84			**336**		336
3	P (4)	**224**	140				84	**336**	30	306
4	C (22)	**224**		224				**336**		336
5	C (22)	**224**	140				84	**336**	30	306
6	C (22)	**224**					224	**336**	80	256
7	C (22)	**336**					336	**336**	119	217
8	C (22)	**336**				168	168	**336**	60	276

*dissolved in gypsum mixer

Application method

The two most important irrigation strategies in Californian almond are drip irrigation and Fan jet irrigation, and a majority of growers are providing N and K fertilisers by injecting water soluble fertiliser in the irrigation water. Yield of Fan jet irrigated trees was modestly higher compared to drip irrigated trees under almost all treatments and fertiliser sources (Figure 1). In drip-irrigated trees the K measured in the leaf tissue in the years three and four, was significantly lower (on average over all treatments over two years 0,4%) than leaf-K of trees with Fan jet irrigation, irrespective of K source. For Trt 5 in year four, the potassium concentration was 2,8% in leaves of the Fan jet irrigated trees and 2,1% in leaves of the drip irrigated trees. The zero K treatment (Trt 1) approached the critical value for almond trees (1,4%) in the majority of the years.

Application frequency

It was demonstrated that continuous fertigation is a viable fertilisation strategy compared to periodic fertigation. When managed correctly, continuous fertigation will reduce the risk of deep nitrate leaching and provides greater flexibility to adjust fertiliser rates in-season. This offers greater control preventing nitrate loss and improves nitrogen management, a benefit given the increasingly stringent requirements to minimise nitrate leaching in Californian agriculture. There was a significant increase in nitrogen recovery when nitrogen was applied using continuous fertigation, especially under Fan jet.

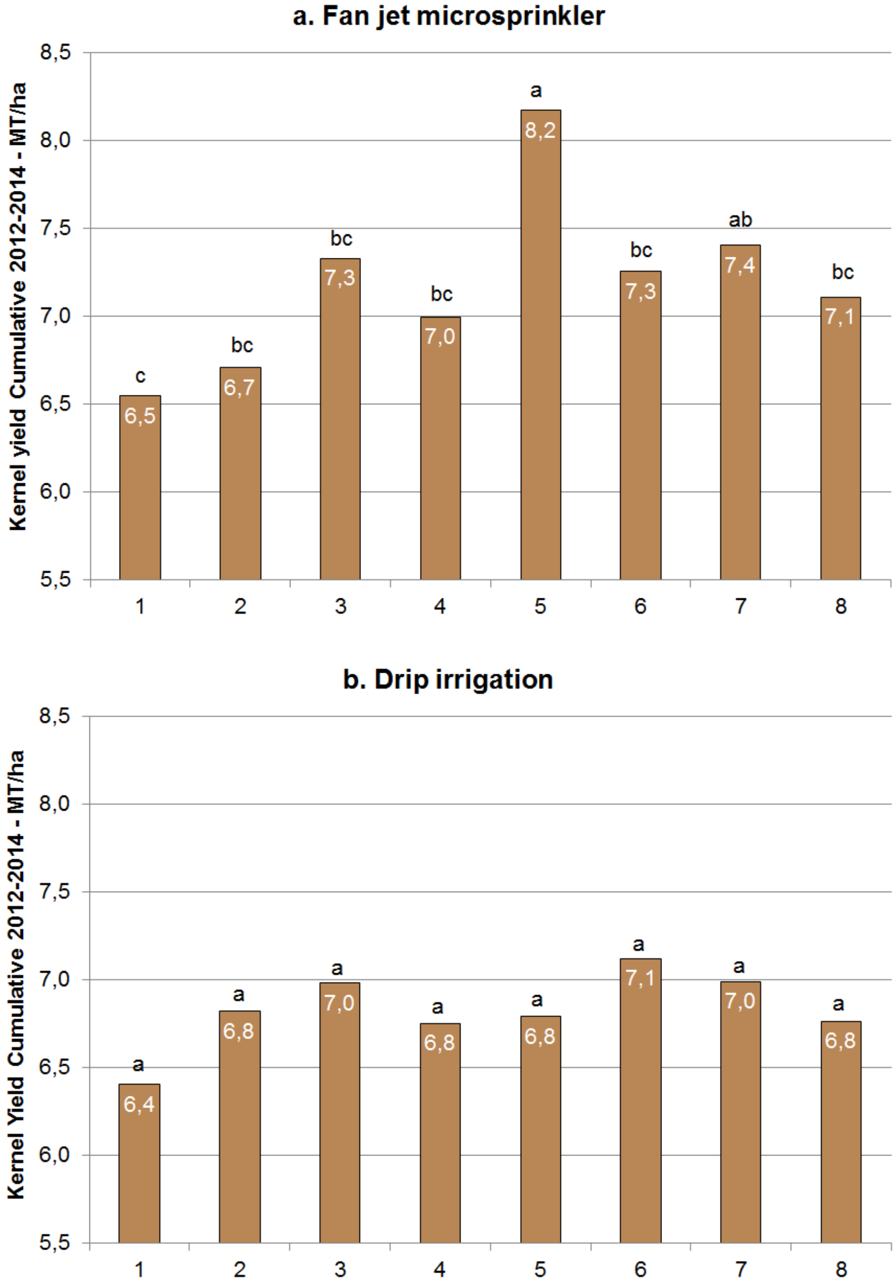

Figure 1 a and b. Cumulative kernel yield over three years (2012-2014) in the commercial almond orchard in Belridge, CA. Comparison between treatments applied with Fan jet irrigation (a) and the same treatments applied through drip irrigation (b). To provide an accurate measure of the yield response to the treatments, the first year (2011) of trial establishment and tree standardization was excluded. The three year average is brought down by a very low yield also in adjacent blocks in 2012. In 2013 and 2014 normal yields were realized (3360 and 4480 kg/ha, resp). Columns labeled with the same letter are not significantly different (LSD, 10%).

Total nitrogen recovery was determined in 2013 for the continuous fertigated (C) and pulse fertigation (P) treatments supplied with 60% of required K as banded SOP (potassium sulphate) and 40% K as KN (potassium nitrate) under both drip and Fan jet. Nitrogen recovery is the product of total fruit nitrogen in all fruit parts (hull, shell kernel) multiplied by yield. Results are expressed as kg nitrogen export per hectare or per 1000 kg kernel yield. There was a significant increase in nitrogen recovery when nitrogen was applied using continuous fertigation, especially under Fan jet. This increase in recovery was a consequence of both higher yields as well as higher nitrogen content in the harvested fruit and was equivalent to a recovery of an additional 56 kg per ha and an 13% increase in nitrogen use efficiency. The total N removal on a 1000 kg kernel yield basis was 68 kg in the pulse fertigated treatments (which matches closely with existing guidelines) and increased to an average of 73 kg in the continuous fertigated treatment.

In conclusion, the following 4 R's of almond fertigation can be distilled from the outcome of these trials:

1. Right Source: The inclusion of KN as a proportion of fertiliser in every irrigation is beneficial to yield and total nitrogen recovery. In this trial maximal benefits for both yield and nitrogen recovery were seen at 224 kg/ha total K with 60% of K as banded SOP and 40% of K as KN, and 336 kg/ha total N, 308 kg of these as UAN.
2. Right Rate: To achieve optimal efficiency of nitrogen use growers should apply fertilizers at the rate of 68 kg N/1000 kg expected kernel yield. This amount of N is sufficient to replace all the nitrogen exported in harvested product and also provides sufficient N for all vegetative and perennial growth. The efficacy of this treatment however, depends upon N fertilization strategies in which losses through leaching and volatilization are minimal. In these experiments application of 224 kg K/ha resulted in the highest yields and there was no benefit from applications of K at greater rates.
3. Right Timing: Timed according to pattern of N and K uptake by the tree, in every irrigation event during the active uptake period.
4. Right Placement: Fertilisation and irrigation strategies should be designed to retain nitrogen in the shallow root zone where most roots are found. This can be achieved by application in as many split applications as possible and the injection of fertiliser concentrated towards the end of the irrigation event.

Reference:

Brown, P.H., A. Olivos and B. Sanden, 2015. Influence of Fertigation Strategy, Nitrogen and Potassium Source on Root Growth, Plant Nutrition and Productivity in Almond. Report for PNA, in collaboration with UC Davis and University of California Cooperative Extension, 15 p.