NITROGEN DYNAMICS IN SOILS OF ALTERNATIVE FUMIGATION SYSTEMS

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Observations from commercial fields indicated that strawberry plants from fields fumigated with chloropicrin or InLine showed reduced yields at later growth stages compared to fields fumigated with the 2:1 methyl bromide and chloropicrin (MB/Pic) mixture. Yield reductions could be related to (1) reduced pathogen control by alternative fumigants, (2) proximity of planting time relative to fumigation time, and (3) reduced nutrient (especially N) availability in soils due to fumigant-related changes in microbial populations. Nitrogen availability in soils is controlled by microbial mineralization processes, whereby organic N compounds are converted into mineral or plant-available N forms (i.e., ammonium and nitrate). Previous studies indicated soil fumigation with MB and alternative fumigants decreased nitrification by 75 to 99% up to 4 weeks past fumigation. Understanding different rates of nitrogen mineralization in soils fumigated with methyl bromide and alternative pesticides are important to precisely schedule amounts and timing of fertilizer applications throughout the growing season to meet the N demands of the plants, and to avoid nitrogen losses through leaching into the water table, resulting in contamination of wells and groundwater supplies. Therefore, the objectives of this study were to evaluate the effect of a) different fumigants (MB/Pic mixture, chloropicrin, InLine), b) planting times, and c) N fertilization rates on strawberry yield, fruit quality and N availability in soil.

Materials and Methods

Field studies were conducted on sandy loam soils in the central coastal region of California at the UC Davis Pomology Research Station at Watsonville and at a commercial field at Oxnard. Commercial cultural practices for the area were followed. Soil beds (300 ft long) were formed at 52” (32” wide x 12” high) and 70” (48” wide x 12” high) center-to-center. Slow release pre-plant fertilizers were applied during bed shaping. Drip irrigation systems used consisted of two drip tapes with emitters spaced 12” apart and an emitter flow rate of 1.5 L/h at 70 kPa. Each drip tape was placed 4” (Watsonville) and 12” (Oxnard) from the bed center at a soil depth from 0.8 to 2”. The experiment was designed in a split-split plot design with the fumigants randomized between 4 blocks. Each fumigant, factor A, was assigned to a whole plot within a block, each plot was subdivided for planting time, factor B, 8-9 weeks or 4 weeks past fumigation, and subdivided again for N fertilization rate, factor C, 0, 1 or 2 times growers standard. Fumigants were applied at the following rates: 400 lb/A MB/Pic, 300 lb/A Pic, and 300 lb/A Inline.
At 8 and 4 weeks after fumigation, bareroot strawberry (*Fragaria* X *ananassa* Duchese, variety “Diamante” was transplanted. Supplemental fertilizers (Calcium Ammonium

Nitrate, K_2O, and P_2O_5) were applied through the drip irrigation system over the entire growing season for the 1 and 2 times fertility rate, and water for the 0 fertility rate.

Strawberry growth was monitored by measuring stand counts (Oxnard) and plant foliage diameter (Watsonville). In Watsonville, foliage nutrient (N, P, and K) content was determined on leaf blade and tissue samples. Fruit yield and quality (e.g., fruit appearance and size, Watsonville only) were determined on a weekly basis from March to October 2005 and 2006 for Watsonville, and from January to May 2006 for Oxnard. Soil NO_3-N concentrations and supply rates were determined on a monthly basis from August 2004 to August 2006 (two growing seasons) at Watsonville and from August 2005 to June 2006 (one growing season) at Oxnard by a combined soil extraction method (1 M KCl extract) and ion exchange resin technique (PRS^{TM} anion probes, Western Ag Innovations Inc., Saskatoon, Saskatchewan, Canada), respectively. PRS^{TM} anion probes were buried at 0-6 and 6-12" depth in the crop row of raised beds to monitor soil NO_3-N supply to the plant over the entire burial time. Soil samples were collected at the same depths and bed locations and extracted with KCL in the laboratory to determine soil NO_3-N concentration at sampling time.

Results

Plant numbers and foliage nutrient contents, as shown by the N, P and K content of leaf blade samples were similar in plants from nonfumigated and fumigated field plots, and from MBCP and chloropicrin fumigated plots. Also, fertilization rate did not affect N, P, and K contents of plant samples (data not shown).

Total strawberry yield and fruit quality in nonfumigated control plots were significantly lower than in fumigated plots. However, no differences in fruit yield and quality parameters (i.e., marketability, fruit uniformity, color, shape and size) were found between the MB/Pic and the two alternative fumigants studied after one growing season. Also, planting time and fertility rate had no effect on fruit yield and quality (Tab. 1).

The comparison of NO_3-N concentration and NO_3-N supply rate data in initial soils (i.e., prior to the field trial) showed a close relationship between results obtained from traditional soil extracts and an ion exchange resin technique (Fig. 1). Therefore, PRS^{TM}-probes can be used as a simple tool to measure available soil nitrate during the growing season to schedule fertilizer applications.

At Oxnard, lower soil nitrate supply rates were found in InLine fumigated soils up to two months after planting and at harvest begin (January 2006) relative to the standard MB/Pic treatment (Fig. 2). Soil fertility rate influenced soil nitrate supply rates. Initially similar soil nitrate were measured in plots under 0, 1, 2x fertility rate. However, at harvest begin highest soil nitrate rates were measured in the 1x fertility treatment. Soil nitrate supply rates were similar at 6" and 12" soil depth.

Results from the Oxnard trial suggested that the proximity of plant-back time is important for nutrient efficiency of strawberry plants. Supplemental fertilization appeared to be less important for strawberries transplanted 8 weeks past fumigation than for those transplanted 4 weeks past fumigation. When cumulative N supply in soil is compared to relative fruit yield, then strawberries planted closer to the fumigation treatment (i.e., 4 weeks past fumigation) showed higher nutrient efficiencies (Table 2).

Table 1. Strawberry yield and fruit quality of the 2004/2005 growing season at the Watsonville fertility trial.

Fumigant [Plant-back wks]	N-Rate	Total Yield (g/plant)	Avg. Appearance	Avg. Size (g/fruit)
Control	1	1254a	3.5a	27.2a
	2	1353a	3.5a	27.7a
MB/Pic [9]	1	2238b	3.7b	32.1b
	2	2246b	3.7b	32.1b
MB/Pic [4]	1	2142b	3.8b	32.1b
	2	2152b	3.9b	32.0b
Pic [9]	1	2306b	3.8b	32.3b
	2	2256b	3.8b	31.8b
Pic [4]	1	2264b	3.8b	32.7b
	2	2079b	3.7b	31.8b

Figure 1. Soil NO_3-N concentration versus NO_3-N supply rates in initial soils (prior to fumigation) in the fertility trial at Watsonville.

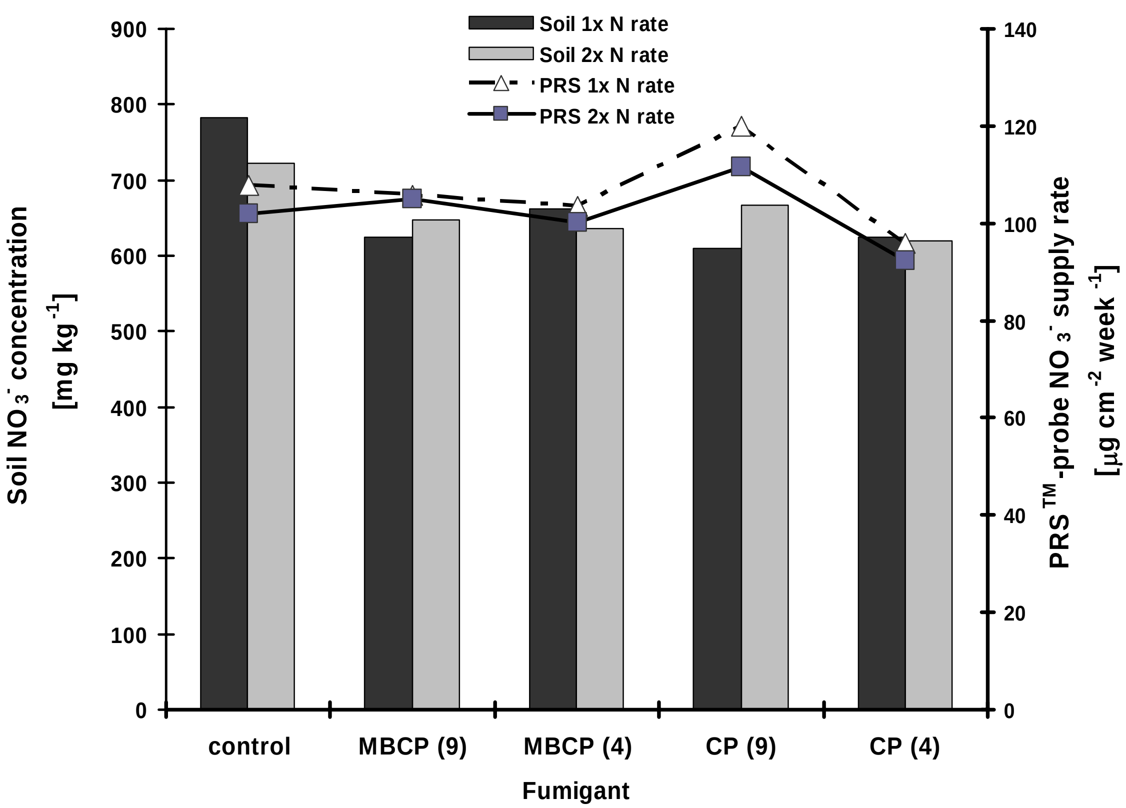

Figure 2. Dynamics of NO3-N supply rate in untreated and fumigated soils at Oxnard (October 2005 to May 2006)

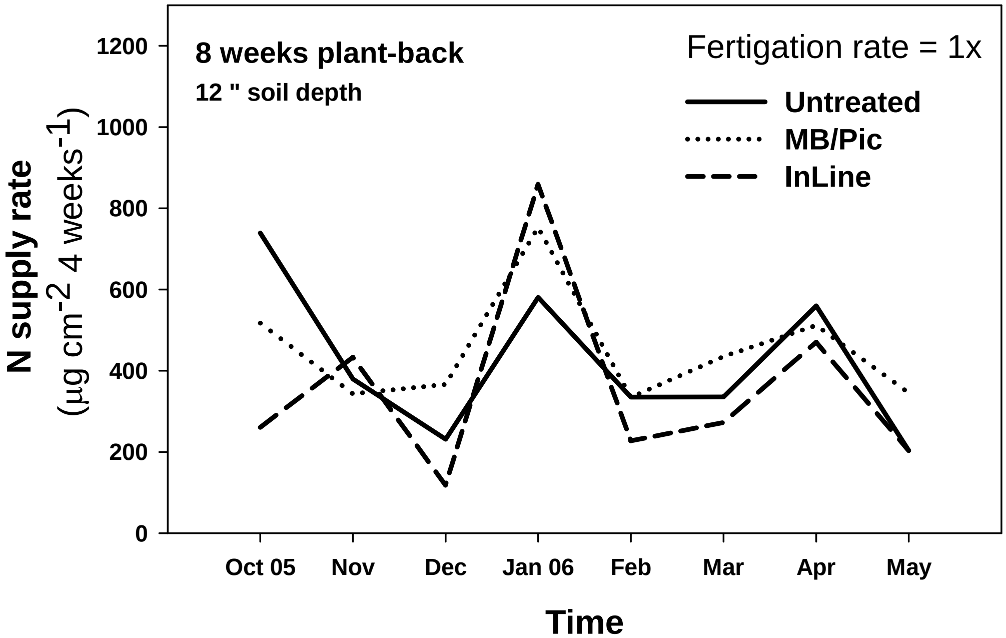

Table 2. Relative cumulative soil nitrate supply and yield in Oxnard soils (October 2005 to May 2006)

Fumigant		MB/Pic			InLine		
Fertility Rate		0	1	2	0	1	2
4 weeks plant-back							
soil depth	6"	86	109	123	95	106	98
	12"	104	110	125	128	117	108
Yield		104	106	108	103	106	105
8 weeks plant-back							
soil depth	6"	144	141	137	109	128	111
	12"	146	144	146	123	114	110
Yield		105	102	102	110	106	110