Nematode Management and Soil Fumigant Research : Prefumigation Soil Moisture Conditions

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I thought it was appropriate to follow up on some thoughts and grower discussion we had at the recent Fumigation Clinic in East Palatka regarding prefumigation soil moisture conditions and the impact it has on fumigant retention in soil and potato yield. At this meeting I was reporting on some first year soil fumigation results where we established moisture gradients (dry, semi-wet, wet) at two different farms prior to shank application of four different fumigants (Telone II, Telone C17, Telone C35, PicClor 60) (**Fig. 1**) using multiple tanks of water from a tractor drawn watering tank and drenching boom. After creating the moisture gradients, which were very different in soil moisture content at the two farms (Figure 1), we then soil injected the fumigants through the different dry, semi-wet, and wettest zones at each field location. The following day, we (mostly Steven Lands & Mark Warren) started monitoring and recording soil air concentrations of 1,3-D at two depths (6 and 12 inches) and two bed locations (bed center, midway between bed center and bed shoulder) within each fumigant replicate plot until it disappeared from soil. For most of the month of January, soil air measurements were taken 3 times per week for the 3 different moisture levels, 4 fumigants, and 4 replications per treatment. This was a lot of work, and you should know of and commend our two agents for such dedication and service.

After the soil air measurements were collected, the data was then input to computer file and statistically summarized by fumigant treatment, soil depth, bed location, and calendar date. Graphically, two dimensional X and Y axis plots were made of 1,3-D concentration and calendar date to mathematically describe soil dissipation, the decrease of 1,3-D gases from soil with time. Once the soil dissipation curve for a given fumigant treatment, depth, and bed location was determined, the area under the dissipation curve (AUDC) was calculated to determine cumulative fumigant dosage. This was calculated to summarize the sum of the Concentration times Time (CxT) products from the time the fumigant was applied until it's near complete disappearance from soil. As a measure of dosage, AUDC captures the changes in soil air concentration over time but also the length of time required to aerate the soil of 1,3-D under the different dry, semi-wet, and wet soil moisture regimes.

For these experiments our objective was to hold the application rate of Telone (1,3-D) constant across formulations and to increase the use rate of chloropicrin per acre to determine the yield and tuber quality benefit of chloropicrin, if any. A second objective was to study the importance of prefumigation soil moisture conditions. You might ask - Why study prefumigation soil moisture conditions? There are actually many reasons, and we will elaborate on a few. For Telone mixtures containing Chloropicrin, the new fumigant label requirements for Good Agricultural Practices (GAPS) requires a minimum soil moisture condition to be met prior to soil fumigation. To comply with the new labels, soil moisture must be equal to or greater than 50% of available water capacity for all shank applications. Available water is the difference between water content at field capacity (maximum) and permanent wilting point (absolute minimum). Field capacity is defined as the amount of water held in soil after excess water has gravitationally drained away. To comply with the new fumigant labels, growers must thus certify on their fumigant management plans (FMP's) that the above soil moisture conditions were present in the field prior to fumigating the field. Other reasons for our interest in studying soil moisture content includes odor management, worker safety, and improved efficacy and yield response with increased fumigant retention in soil.

During last year's studies, we did not observe a significant yield response to chloropicrin above a level of about 10-20 lb per acre (Figure 2). At the Smith farm, Telone C17 (7.5 gpa) under the driest soil moisture regime (12%) produced the highest marketable yield. At Danny Johns where a Corky Ring Spot (CRS) resistant yellow potato variety was planted, we did not see a difference in marketable tuber yield among any fumigant formulation, chloropicrin rate, or moisture level. Without CRS, soil moisture condition did not appear to be important, at least from 7 to 10% soil moisture content. At the Arlie Smith farm where a susceptible red potato was grown and where CRS was a huge problem, prefumigation soil moisture level was a very important determinant of potato yield. At Smith's, marketable potato yields incrementally declined from 12 to 16.5% soil moisture. At the Smith farm, the optimal prefumigation soil moisture condition was probably somewhere between 12 and 14 percent (**Fig. 3a,3b**). Some difficulties were encountered interpreting the Smith data within the wettest moisture regime (16.5% soil water content). This occurred because it was not possible for us to assess soil air concentrations of fumigant gases with our sniffing equipment when the soil was saturated at the 6 and 12 inch soil depths. We cannot allow water to pass into our gas monitoring sensor because it would short circuit the lamp and irreparably damage the sensor. As a result, our measurements of non-saturated soil at the two bed center soil depths (6,12") both reflect a continued increase in fumigant dosage with soil moisture content of the soil. As is typically the case under wet conditions, fumigant escape from soil was delayed (higher AUDC), and fumigant movement was retarded (**Figure 3b**) and effectiveness of the treatment reduced (**Figure 2**). This is exactly what we saw with fumigant persistence in soil and potato yields at the Arlie Smith farm.

At the Danny Johns where prefumigation soil conditions were relatively dry, fumigant dosages across all fumigant treatments and moisture regimes were actually measured to be pretty low. This is because none of the different fumigants persisted in soil at high concentrations for very long. At the John's farm, dosages at the bed center nearly doubled from the driest to the wettest soil moisture condition (from 7 to 10%), demonstrating the higher concentration and enhanced persistence of the fumigants in what was the wettest soil moisture regime at the site (**Figure 2A**). At the midway location on the plant bed, it was also apparent that fumigant dosages were only $1/5^{th}$ those measured at the bed center under these generally dry soil moisture conditions (note different scales on the AUDC Y-axis). This would suggest that under dry conditions, fumigant movement was rapidly upward without much lateral movement toward the shoulder of the packed bed. With a resistant variety it should come as no surprise that no differences in marketable potato yield were observed between fumigant treatments and prefumigation soil moisture condition at the Johns farm. Under these generally dry conditions, 1,3-D dosages were all similar for the two driest moisture regimes, and only increased at the highest prefumigation moisture level of 10.3%.

We would like to conclude this newsletter article with the following summary. A significant increase in tuber yield was not observed in either study above a chloropicrin use rate of 13 lb/a. At the Smith farm, under very wet conditions, soil moisture content above 12% degraded yield performance of all of the different soil fumigants in a high pressure CRS field where a CRS susceptible potato variety was planted. Clearly, where CRS can be a big problem, prefumigation soil moisture can be very important to fumigant efficacy, soil retention of fumigant gases, and yield. Under the drier soil conditions at the Danny Johns farm site, it was the wettest treatment (10.3% soil moisture) which produced the highest fumigant dosages (AUDC) and highest potato yields. Unlike Smiths, the wettest condition at Johns did not cause degradation in performance among fumigant treatments, rather it improved it dosage and yield. Overall fumigant dosages were low and all of the different fumigants disappeared from soil very rapidly at Johns. With a CRS resistant cultivar, Telone II, a fumigant containing no chloropicrin produced the highest yield, and was generally as good as or better than any of the other Telone Chloropicrin mixtures for producing high levels of marketable potato yield. In our minds, the real headline to this story is that these preliminary studies demonstrate the importance of at least 10-12% soil moisture content at the time of soil fumigant application. For a typical Florida fine sandy soil, which these soils represent, it is also quite fortuitous that the 10-12% also corresponds to a level of 50% total available water (field capacity 18% and permanent wilting point 4% soil moisture content), a level required by the fumigant label.

Figure 1. Soil moisture gradients established prefumigation at two farmsgrowing different potato varieties- Hastings, FL - January 2012

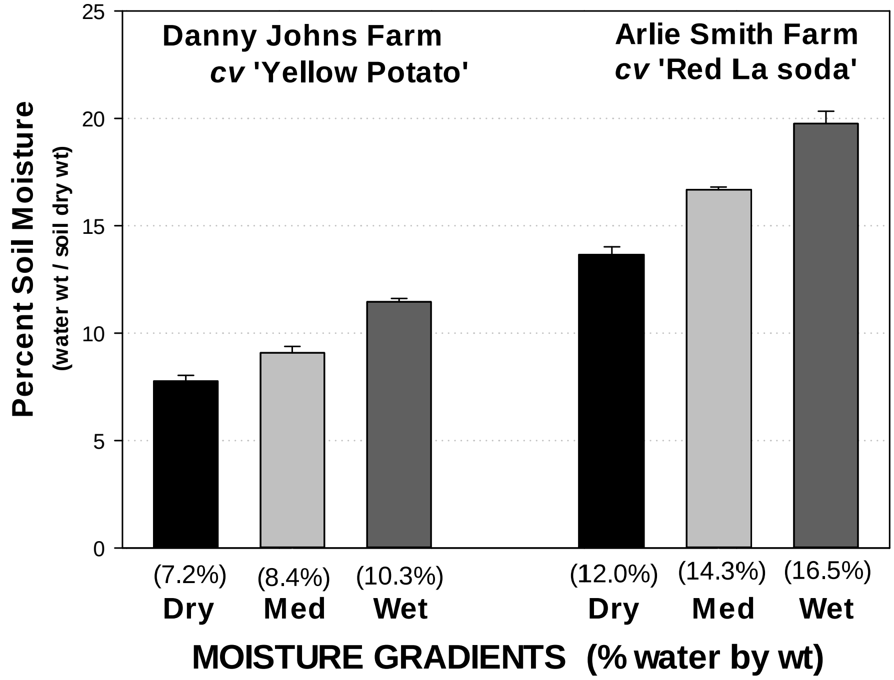
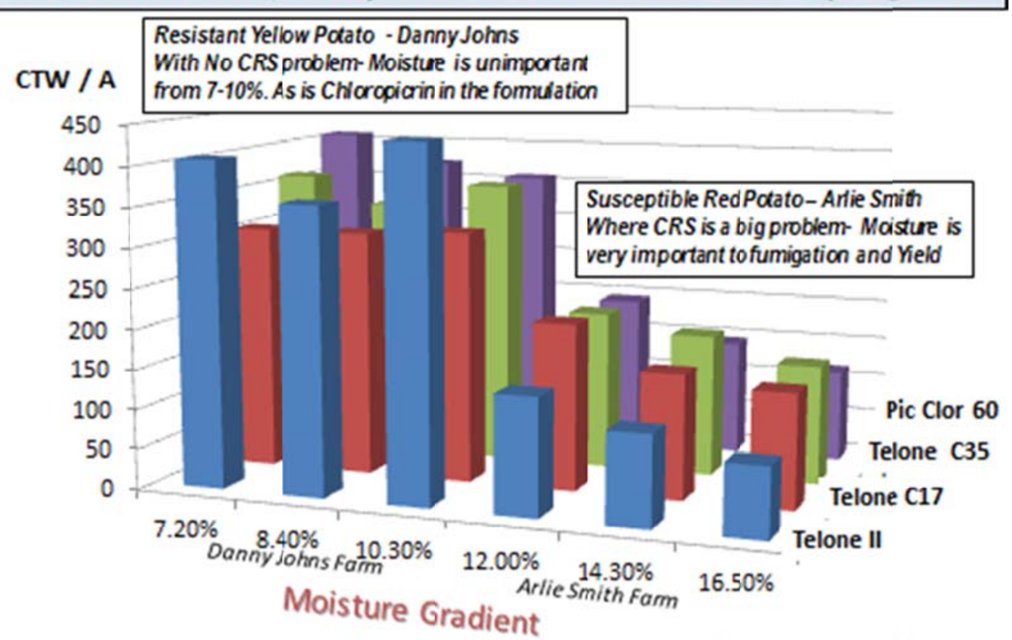


Figure 2. Total Marketable Potato Yields by Moisture and Chloropicrin Level at two farms, Danny Johns and Arlie Smith Farm – Spring 2012



Under very wet conditions, excess moisture degrades yield performance!

Figure 3a. Area Under Dissipation Curve (AUDC) - 6" and12" Soil Depth
Measured at the center of the packed bed
Composite All Fumigants using Smith & Johns Farm Datasets 2012

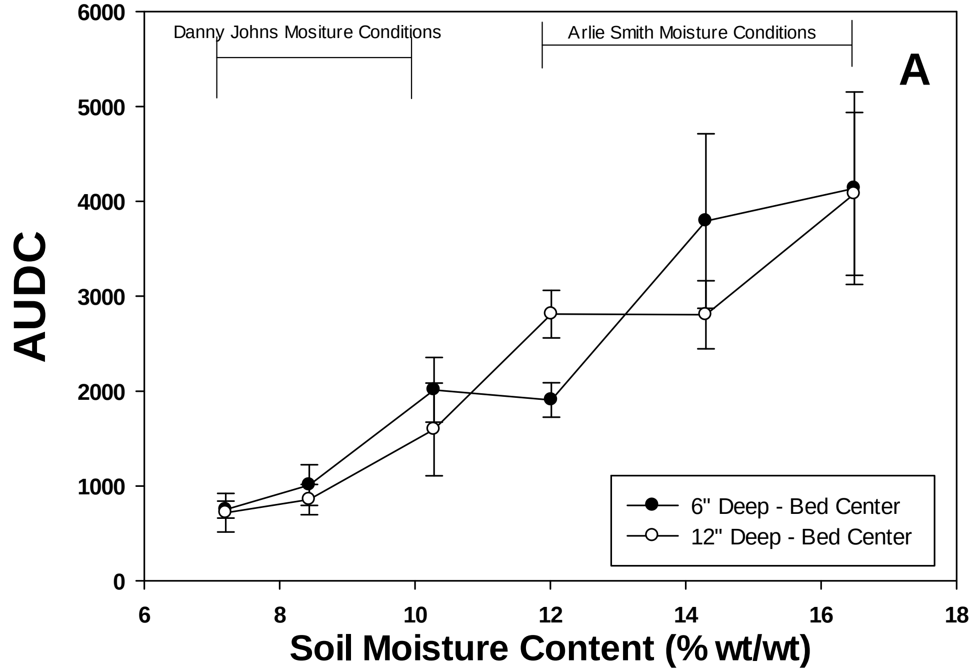


Figure 3b. Area Under Dissipation Curve (AUDC) - 6" and12" Soil Depth-
Measured Midway between bed center and bed Shoulder
Composite All Fumigants using Smith & Johns Farm Datasets 2012