WATER AND NUTRIENT DISTRIBUTION WITH DRIP-IRRIGATED WINE GRAPES

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ABSTRACT

Drip irrigation is a valuable tool in managing the production of high quality Washington State wine grapes. Wample (unpublished data) has demonstrated the importance of early water stress on maintaining the desired canopy. Drip irrigation allows very controlled amounts of water to be added to maintain a given plant moisture stress. In the fall, drip irrigation allows a producer to control moisture stress to develop fruit quality and harden off the vines. However, the use of drip irrigation can lead to challenges when predicting nitrogen needs and soil available nitrogen. This study was done to determine a soil sampling strategy for drip fertigated wine grapes that reflects plant nutrient availability. Bromide was used to simulate nitrate movement through the wetting zone and vines. Bromide was added as part of the first irrigation. Soil sampling zones were established to follow water and bromide movement. Results from soil moisture analysis indicated that variability in water movement patterns among vineyards may require sampling protocols for each vineyard. Bromide results are currently being run and will be reported at the meeting.

INTRODUCTION

Traditionally, soils are sampled and analyzed to predict the amount of nutrient available to a plant over the growing season. One of the challenges in soil sampling is collecting a soil sample that reflects the zone of soil the plant roots will derive nutrients from during the growing season (Brady and Weil, 1999). Numerous strategies have been developed to attempt to best capture the variability in nutrient availability in annual crop fields (Miller and Gardiner, 1998; Crepin and Johnson, 1993). More recently, recognition of the high degree of variability in soils has led to collecting and analyzing multiple samples at known locations throughout large fields which is then followed by variable rate fertilization to account for within field differences (Davenport and Hattendorf, 2000; Pierce and Nowak, 1999).

In all of the sampling strategies described above, there is an assumption of uniform water and nutrient application. Nutrient distribution patterns change when water and nutrients are applied through a drip irrigation system (Burt et al., 1995), necessitating crop specific modifications in soil sampling strategies.

Drip irrigation is a valuable tool in managing the production of high quality Washington State wine grapes. Wample (unpublished data) has demonstrated the importance of early water stress on maintaining the desired canopy. Drip irrigation allows very controlled amounts of water to be added to maintain a given plant moisture stress. In the fall, drip irrigation allows a producer to control moisture stress to develop fruit quality and harden off the vines. However, the use of drip irrigation can lead to challenges when predicting nitrogen needs and soil available nitrogen. Although applying the nitrogen with the irrigation water is a very effective means of application, the nitrogen applied through the drip system is not always plant available. Reduced irrigation levels after nitrogen application may cause the soil nitrogen to be stranded in dry soil where it is less plant available. Because this residual soil nitrogen will be in a pattern developed by the frequency and duration of drip irrigation, it is not uniformly distributed throughout the soil profile. Therefore, improved methods of soil sampling are needed to determine the amount of residual nitrogen left in the soil profile that may become available to the crop during the upcoming season. Proper sampling will also be important in predicting when nitrogen may become limiting prior to reduction in petiole nitrogen levels.

OBJECTIVE

The objective of this project was to determine a soil sampling strategy for drip fertigated wine grapes that reflects plant nutrient availability.

MATERIALS AND METHODS

To determine what zone of soil should be sampled to reflect plant nutrient availability in a vineyard where both water and nutrient management is via drip irrigation, a non-radioactive tracer was used. The tracer element bromine (Br) moves through the soil-plant-water system similarly to the plant nutrient nitrate-nitrogen. In 2002 a potassium bromide solution was applied to drip emitters a set distance from 8 Cabernet Sauvignon grape plants at two different vineyards (16 plants total) at the key growth stage veraison. The bromide powder was placed in a 120 ml plastic cup suspended below an emitter on the elevated drip tubing. Water from the emitter filled the cup dissolving the bromide. The water containing the bromide was then dripped to the soil surface through a hole in the side of the cup. This allowed the bromide to be added slowly at the normal water application rate. Both vineyards were established on silt loam soils. Soil and plant tissue (both leaves and petioles) was collected from 6 plants at each vineyard, 1 and 2 days after the application, 2 days after the next irrigation set, and after the last seasonal irrigation. The two plants not used were available to provide a reserve sampling area in case of a sampling problem (e.g., obstructive layer, rock). Soil samples will be collected in the spring (pre-bud break) following the application and tissue samples collected at bloom to trace the movement of fertilizer from the previous year.

To determine which soil sampling zone location relative to the drip emitter is most closely correlated with plant uptake, soil samples were collected in a half circle radial pattern around the emitter (16 locations) at three depths - 0 - 15, 15 - 30, 30 - 45 and 45 - 60 cm - (Figure 1) so that a three dimensional picture of Br could be developed.

At the time of sample collection, each soil sample was collected into a pre-weighed soil sample can. The can was closed, and once each collection was completed, the cans were weighed. The can plus soil were dried at 105^{o}C for a minimum of 24 hours, then the can plus dry soil re-weighed to allow the calculation of soil moisture.

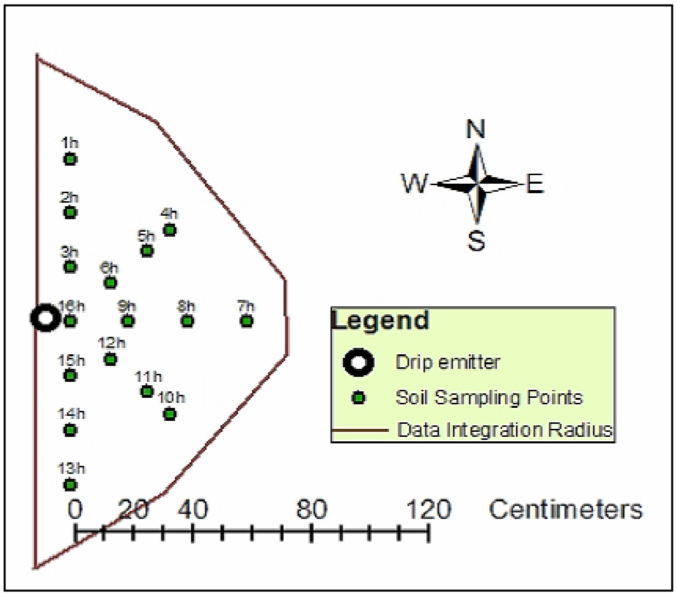

Figure 1. Diagram of soil sampling locations relative to drip emitter with 20 cm between sampling points.

Bromide extractions were performed using a deionized water extractant. In the literature a 1:1 ratio of 20 g of field moist soil to 20 ml of water was used for extraction (Paramasivam et al., 2002). Since soil moisture data was collected and the soil samples were dried, the water used for the extraction was increased to 30 ml. The samples were shaken for 30 minutes in a 50 ml centrifuge tube, centrifuged for 10 minutes at 3270 x g followed by the supernatant being filtered through a Whatman (Maidston, UK) 42 filter paper. Bromide analysis was performed by colorimetric analysis on a continuous flow auto analyzer (Alpkem Flow 3000, OI Analytical, College Station, TX). In the analysis, bromide is oxidized to bromine by chloramines T (Thomas and Chamberlin, 1980). The bromine is then taken up by flourescein resulting in a red/pink color measured at 520 nm.

Petiole and leaf samples were dried at 60 C and ground to pass 20 mesh screen. Bromide content was determined using a water extract and analysis procedure similar to that used for the soil samples. The study was repeated in 2004 with two Merlot vineyards also located on silt loam soils.

RESULTS

In central Washington State, vegetative growth on wine grapes is regulated by deficit irrigation using drip-irrigation. Therefore, early in the growing season, when vegetative growth predominates, the soil profile is maintained at low soil moisture content. Irrigation practices for each vineyard are established each year based on climatic conditions, variety, desired vegetative growth, planned crop load, and other criteria that might be specified by the winemaker. There is no standard for the amount of water added at any irrigation or whether the water is applied in one application or in a split application. Therefore, no attempt was made to standardize the irrigations during the study. Irrigation timing, amount, and duration were determined by the individual vineyard managers. Bromide was applied at verasion. Therefore, background soil moisture levels were very low at this time due to deficit irrigation.

As can be seen in Figures 2 and 3, the first irrigation in all four vineyards wet only the soil directly below and adjacent to the emitter location. Thirty six hours after the initial irrigation increased, soil moisture was found 0-30 cm below the surface in the center of the wetting zone. Vineyard B in 2004 was significantly drier throughout the study. Because of placement of the emitters and shape of the raised area in the plant row, visual observations suggested that more water was moving to the other side of the wetting zone in this vineyard.

Significant variability can be seen (Figures 2 and 3) in the soil profile 36 hours after the second irrigation. In all cases an increase in soil moisture was seen. Final irrigation is generally used to significantly wet the root zone for winter root protection. The data shows that there are significant differences in what vineyard managers believe is necessary for a final irrigation. The post winter sampling in 2003 showed that moisture had moved through most of the sampled zone with the potential for moving residual bromide or nitrate with it.

Soil moisture sampling in four vineyards demonstrated the variability that occurs in water distribution from drip emitters especially into dry soils. These results indicate that a sampling pattern would need to be developed for each vineyard. Bromide movement during the study will help determine if a standard sampling protocol could be developed.

The potassium bromide of the study in 2002 was supplied by research collaborators. When soil and plant analysis was initiated it was determined that no bromide had been applied. A new source of bromide was used for the 2004 study. Analysis of soil and plant tissue is currently being done and results will be reported at the meeting.

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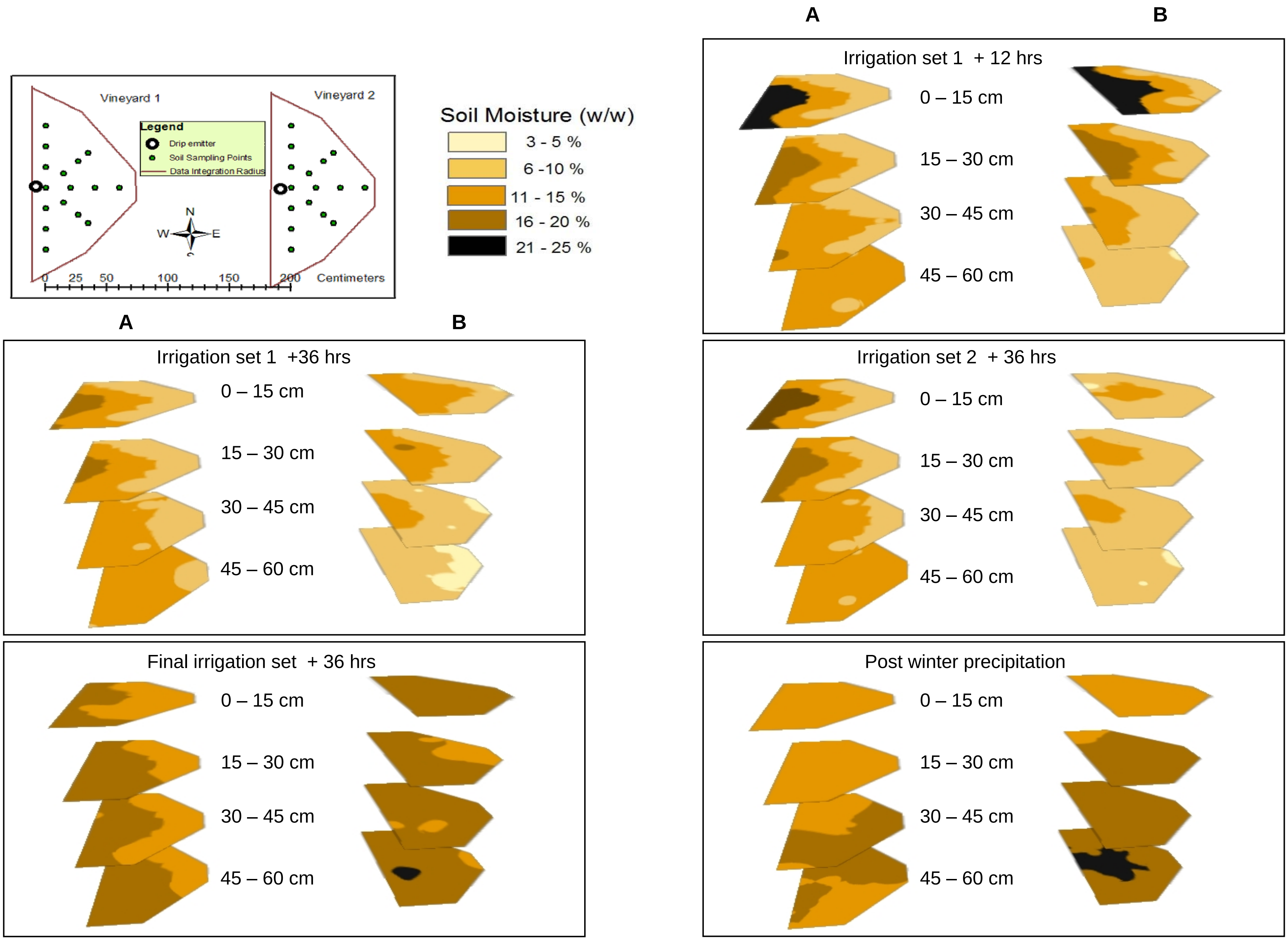

Figure 2. Average soil moisture (n=6) for each vineyard (A & B) at each sampling time by sample depth. Data was integrated across the sampling area using inverse distance weighting with 4 nearest points in ArcGIS ArcScene (ESRI, Redlands, CA) in 2002.

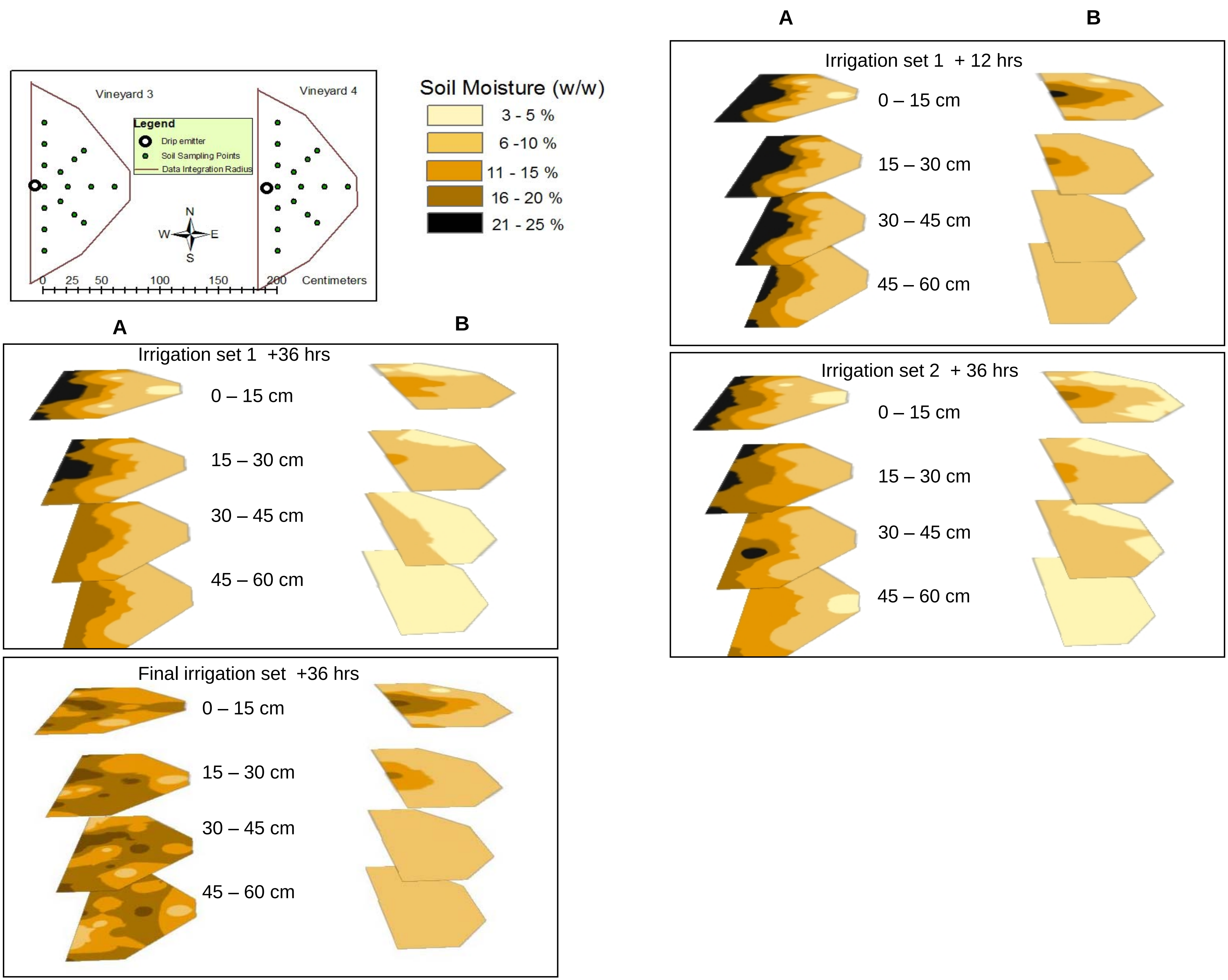

Figure 3. Average soil moisture (n=6) for each vineyard (A & B) at each sampling time by sample depth. Data was integrated across the sampling area using inverse distance weighting with 4 nearest points in ArcGIS ArcScene (ESRI, Redlands, CA) in 2004.