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Nutrient Digest

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SOIL QUALITY AND THE BENEFITS OF CROP ROTATION, REDUCED TILLAGE, AND MANURE APPLICATION

By Jay Norton & Rajan Ghimire - University of Wyoming

Organic materials differentiate soil from plain old dirt. Soil organic matter (SOM) is the crucial element of soil quality that stores carbon (C), drives soil nutrient and water supplying capacity, and binds soil particles to resist erosion and facilitate water infiltration. During the first century of farming, soils in the western US lost as much as 70% of the SOM that had accumulated for centuries under grass- and shrub-land vegetation (Davidson and Ackerman, 1993; Norton et al., 2012), which decreased productivity and increased needs for inputs of water and fertilizer. Since then realization of the value of SOM for such things as conserving water quality and slowing global warming off-farm and supporting productivity and minimizing inputs on-farm have led to development of production strategies that rebuild SOM (Ghimire et al., 2013).

Two underlying strategies toward building SOM include conserving it by reducing tillage and adding it by applying composted manure or other organic amendments. Crop rotation is also thought to build SOM by supplying diverse crop residues, especially if perennial nitrogen (N)-fixing legume crops, such as alfalfa, are included. Starting in 2009 we conducted a four-year experiment on irrigated fields at the University of Wyoming Sustainable Agriculture Research and Extension center in southeastern Wyoming to evaluate impacts of combining crop

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YEAR-TO-YEAR INTEGRATION OF YIELD RESPONSE TO FERTILIZER APPLICATION IN TREE FRUITS

By Grant Cardon, Brent Black & Sean Rowley - Utah State University

Utah has a small, but regionally (and nationally, in the case of tart cherry) significant tree fruit industry producing over $23 million in orchard receipts (US Census Bureau, 2009) from about 8,000 acres statewide (42% tart cherry, 23% peaches, 21% apple, with the remainder in sweet cherries, apricots, pears and other minor crops; USDA-NASS, 2007). Hence, establishing proper interpretive guidelines for sufficient soil and tissue nutrient levels is vitally important in managing and maintaining orchard productivity and, thus, continued viability of this important industry.

However, review of soil and tissue nutrient sufficiency information used in the state and regionally (through use of USU Analytical Laboratory services) indicates that the interpretive values are derived primarily from data generated in Oregon, Pennsylvania and New Jersey (James and Topper, 1993). As a result, under support from the Utah Horticulture Association, the Utah Department of Agriculture and Food, the USDA Specialty Crop Block Grant

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Head Editor – Amber Moore, University of Idaho; Guest Editor – Grant Cardon, Utah State University

Year-to-Year Integration of Yield Response, cont. from pg 1

Program and the International Plant Nutrition Institute, a study was initiated in 2010 to validate and strengthen interpretive information by reconciling current fertilizer recommendations based on out-of-state research, with soil and tissue nutrient data taken from fertilizer rate-response trials under Utah-specific soil and climate conditions.

The importance of this undertaking notwithstanding, observing the effects of fertilization in perennial tree fruit crops is complicated by the integration of antecedent soil fertility and tree nutrient status that greatly influence bud set, winter hardiness and overall fruiting potential in any given season. Thus, data from traditional annual rate-response trials in perennial crops can often be difficult to interpret given the effect of compounding year-to-year fertility conditions on the overall health and productivity of an orchard. A number of fruit species (apple, pear, plum, prune, apricot, cranberry and blueberry) are particularly susceptible to alternate bearing cycles where antecedent fertility and plant condition produce feedback that limits growth and yield in years following larger crop loads (Dennis, 2003). For instance, in apples, high nitrogen availability in a given season promotes excessive growth that can trigger a competitive imbalance toward fruit production and away from bud formation so critical to determining yield potential in the subsequent year.

In 2010 and 2011, a randomized block experiment of fertilizer rate and formulation response on tart cherry yield, fruit quality, and soil and tissue nutrient levels was set up. To account for year-to-year integration effects, treatments were applied at a minimum of six replications on five sites that ranged from an orchard previously receiving annual NPK fertilizer applications per university recommendations, to orchards that previously received fertilizer applications only when obvious deficiencies or yield swings were observed, to an orchard that previously had not received any fertilizer applications over the life of the trees. Effort was made to ensure that the orchards were of similar age (15-20 years) so as to be at the peak of production.

No significant difference in yield as a function of fertilizer application rate was found in the previously annually fertilized orchard, indicating that nutrient sufficiency levels were likely already present. Though only bordering on significance (p-level approximately 0.11) clear trend of higher yield response to increasing application rates of P fertilizer was observed in the orchard that was not previously fertilized (Figure 1). Similar trend in fruit quality was also observed over the range of antecedent orchard fertility management.

Soil nutrient levels were sampled at the beginning and end of each season and plant tissue samples were taken Continued on page 3

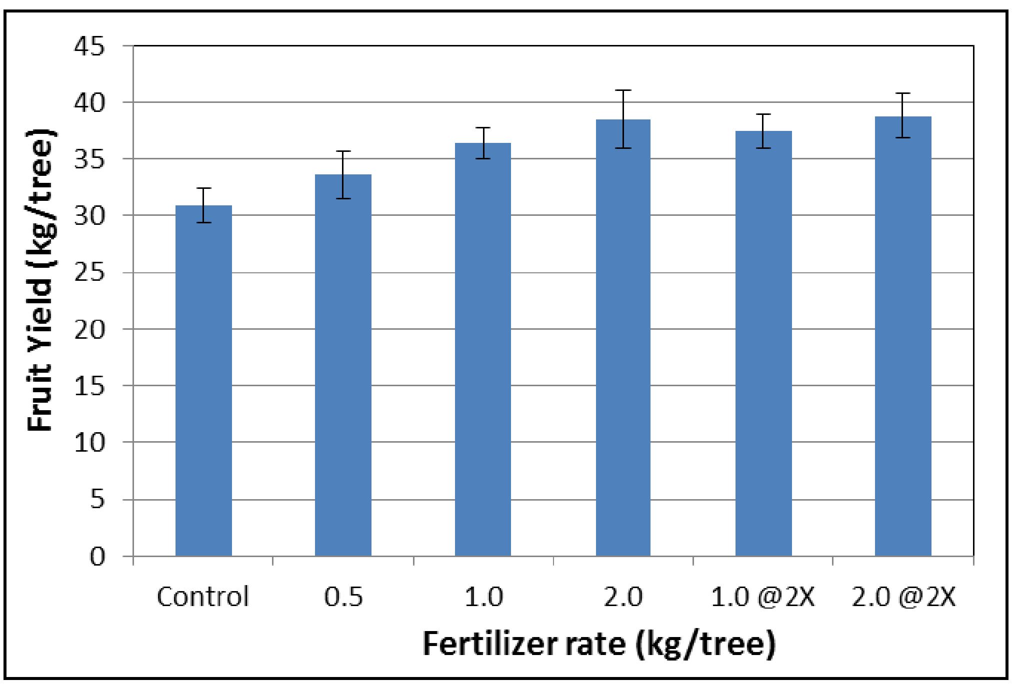


Figure 1. 2011 Yield as a function of applied P for the previously unfertilized orchard.

Year-to-Year Integration of Yield Response, cont. from pg 2

every two weeks from the onset of bloom through two weeks post harvest. This soil and tissue data is being evaluated and reconciled with current university interpretations and recommendations as part of an ongoing MS student thesis. A significant and important practical outcome of the research to date, however, is the observation of the dramatic influence of compounded year-to-year effects of nutrient management on the productivity of perennial orchard crops as illustrated in Figure 2. The three sets of data represent the mean yield response over the specific rates of P application (0.0, 0.5, 1.0 and 2.0 kg/tree, left to right) in the previously annually fertilized (Site A), periodically fertilized (Site B), and unfertilized orchard (Site C). The average yield over all treatments of the previously annually fertilized orchard is fully three times that of the previously unfertilized orchard—a difference not likely to be overcome over the remaining life of the orchard. Even though no statistically significant annual seasonal benefit of fertilizer application was observed, there is a clearly significant compound effect of fertilization on overall orchard productivity which is not easily detectable from annual response data or visual inspection of the orchard (tree size, condition, etc.).

Careful fertility management, therefore, is not only one way of moderating swings in yield from year to year, but annually balancing soil and tissue nutrient levels is a key best practice for obtaining stable, economically optimal production over the life of the orchard.

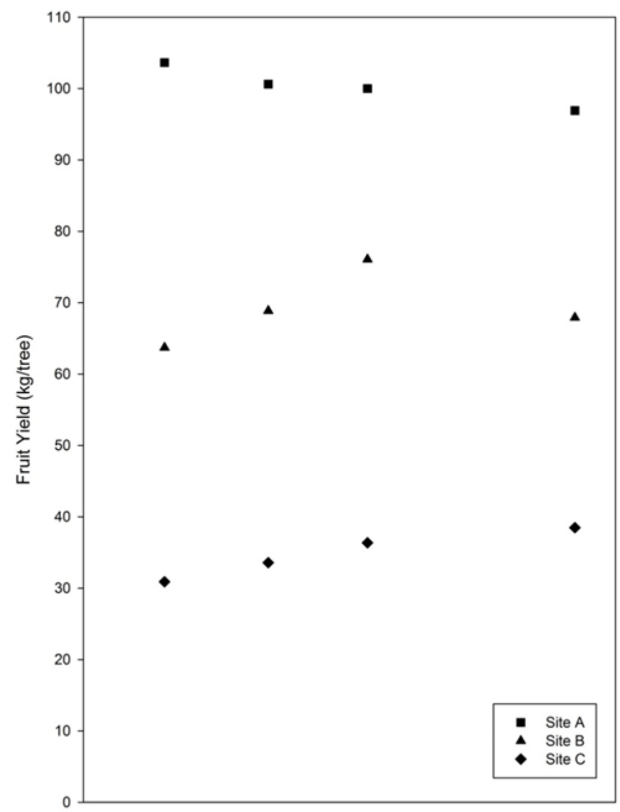


Figure 2. Effect of year-to-year cumulative fertility effects on orchard production potential (Site A: annually fertilized orchard; Site B: periodically fertilized orchard; Site C: previously unfertilized orchard).

References:

Dennis, F. Jr. 2003. Flowering, pollination and fruit set and development. In: D.C. Ferree and I.J. Warrington, eds. Apples: Botany, Production and Uses. CABI Publishing, Cambridge, MA. Pp. 153-166

James, D.W. and K.F. Topper. 1993. Utah Fertilizer Guide. Utah State University Extension Publication AG 431. Logan, Utah.

US Census Bureau, Population Division. 2009. National and state population estimates. http://www.census.gov/popest/estimates.html. Retrieved on April 10, 2011

USDA-NASS, 2007. Census of agriculture: Utah. United States Department of Agriculture National Agriculture Statistical Service.

rotations, reduced tillage, and manure application on SOM-depleted soils that had been under intensively tilled continuous corn for many years (Ghimire, 2013).

We divided the area into 12 one-acre plots and converted four plots to a conventionally managed rotation of dry beans-corn-sugarbeet-corn, four plots to reduced-tillage under the same rotation, and four plots to an organically managed rotation of alfalfa-alfalfa-corn-dry beans. Tillage was similar among the conventionally and organically managed plots and fertility management was similar among the conventional and reduced-tillage plots. Tillage on the conventional and organic plots included moldboard plow, disk, and harrow for seedbed preparation and cultivation as needed for weed control. The reduced-tillage plots were tilled once with a Landstar machine (Kuhn Krause, Inc., Hutchinson, KS). Conventional and reduced-tillage plots were fertilized with commercial fertilizers based on soil-test-based recommendations, while the organically managed plots were fertilized with composted and fresh cattle manure applied based on crop needs for soil N (about 5 tons per acre). Yields were comparable among the three systems, and economic analysis indicates that the organic rotation is more profitable than the other two if premiums for organic-certified crops are considered. To assess effects on soil quality, we measured SOM components that respond relatively rapidly to changes in management, including microbial populations by phospholipid fatty acid analysis, soluble organic C and N compounds, and easily decomposed SOM measures as the portion that decomposes during two-week incubations in the lab.

Results indicate that converting from monocropped corn to crop rotations had the largest positive impacts of the three strategies, and that reduced tillage, manure, and alfalfa in rotations added to the positive effects. At the end of the four-year study total microbial biomass in the soil had increased by factors of three to four in all three systems, with the largest increase in the organic system (Figure 1). The most striking increases in microbes were among fungal species that break down crop residues, with five- to eight-fold increases in that group. Mycorrhizal fungi also increased in all three systems by factors of two to four. Mycorrhizal fungi form symbiotic relationships with plants and support improved uptake of water and nutrients. Both types of fungi form extensive networks of microscopic hyphae that hold soil particles together and improve soil structure, porosity, and water infiltration. Their presence indicates more stable and resilient SOM systems. Overall microbial diversity also increased by 50 to 70% over the four years, indicating presence of a rich Continued on page 5

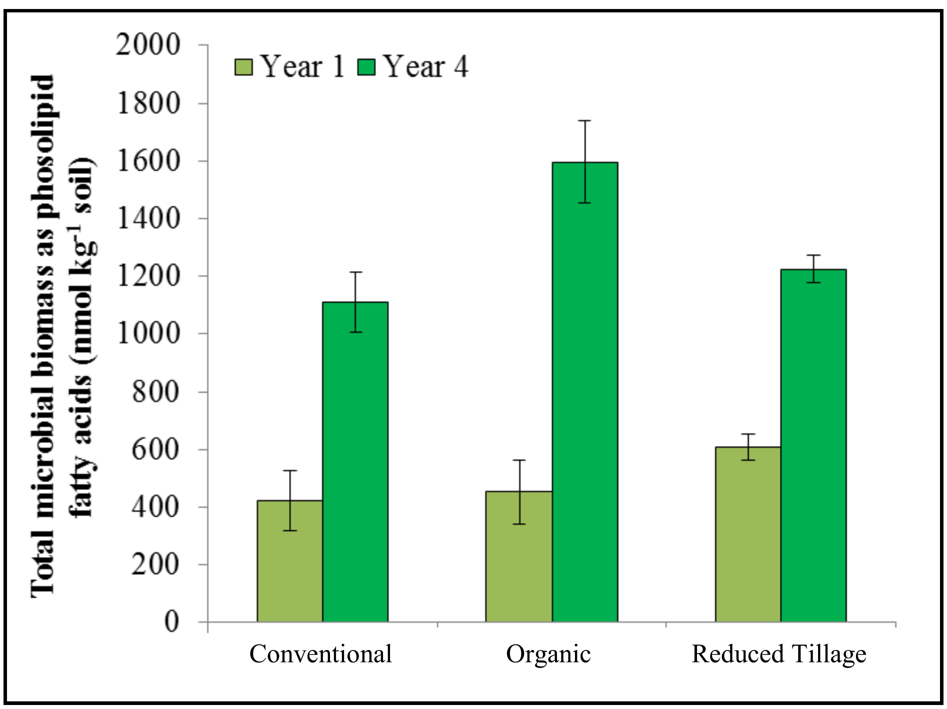


Figure 1. Change in total microbial biomass under alternative management systems after a four year period.

NUTRIENT DIGEST NEWSLETTER RECEIVES THE ASA EXTENSION EXCELLENCE AWARD

By Amber Moore - University of Idaho

Out of four newsletter submissions, the Nutrient Digest Newsletter was selected to receive the ASA Extension Award in the newsletter category. The judges commented that they were particularly impressed by the guest editor structure of our newsletter, in which we alternate the guest editor position among nutrient management specialists in the Western United States. The guest editor serves to both collect current nutrient management articles relevant to the West, as well as editing each article for grammar and content. The addition of the guest editors has allowed us to include a wide array of articles each issue, serving the extremely diverse nature of nutrient management in the western states. Without our guest editors, I am certain that our newsletter would not be as well received or as successful as it has been. I would also like to acknowledge University of Idaho Administrative Assistant Susan Kelly, who handles all of the newsletter formatting, is responsible for creating a professional appearance, and helps to arrange complicated information in such a way that it is much easier to follow and understand. We greatly appreciate this recognition from ASA, and we hope that this recognition will help to strengthen the adoption and application of information generated in this publication.

Soil Quality & the Benefits of Crop Rotation, cont. from pg 4

SOM system with abundant beneficial organisms.

These increases in microbial numbers and diversity correspond to increases in decomposable SOM that serves as substrate – or food – for microbes. Dissolved organic C, which represent sugars derived from initial decomposition of plant residues, increased six-fold by the end of the fourth year, with larger increases under organic and reduced-tillage than conventional management. Dissolved organic N, however, did not increase appreciably, meaning that the C to N ratio of the most microbially available substrates doubled or tripled in the three systems. This change likely results from more diverse types of residue inputs and explains the larger response by fungi during the four-year experiment. The amount of easily decomposable SOM increased by over 50% in the organic system but stayed relatively stable in the reduced-tillage and conventional systems, indicating that the combination of manure and alfalfa in rotation has begun to build SOM more rapidly than rotations alone or reducing disturbance.

Results of this four-year study emphasize the importance of rotating crops for maintaining soil quality and productivity. Even with two years of corn and one of sugarbeet – both highly consumptive crops – in the four-year rotation, soil microbial activity and SOM components increased significantly compared with conditions after years of continuous corn. Combining rotation with reduced tillage further boosted microbial activity, as did including alfalfa in the rotation along with amending soils with manure, but rotation itself had the largest impact on soil quality.

For more information on this study contact Jay Norton at the University of Wyoming (jnorton4@uwyo.edu). Or look up Rajan Ghimire's PhD on-line dissertation on the University of Wyoming library Website.

Davidson, E.A., and I.L. Ackerman. 1993. Changes in soil carbon inventories following cultivation of previously untilled soils. Biogeochemistry 20:161-193.

Ghimire, R. 2013. Soil organic matter and soil microbial communities in long-term and transitional crop and forage production systems in eastern Wyoming. PhD, University of Wyoming, Laramie.

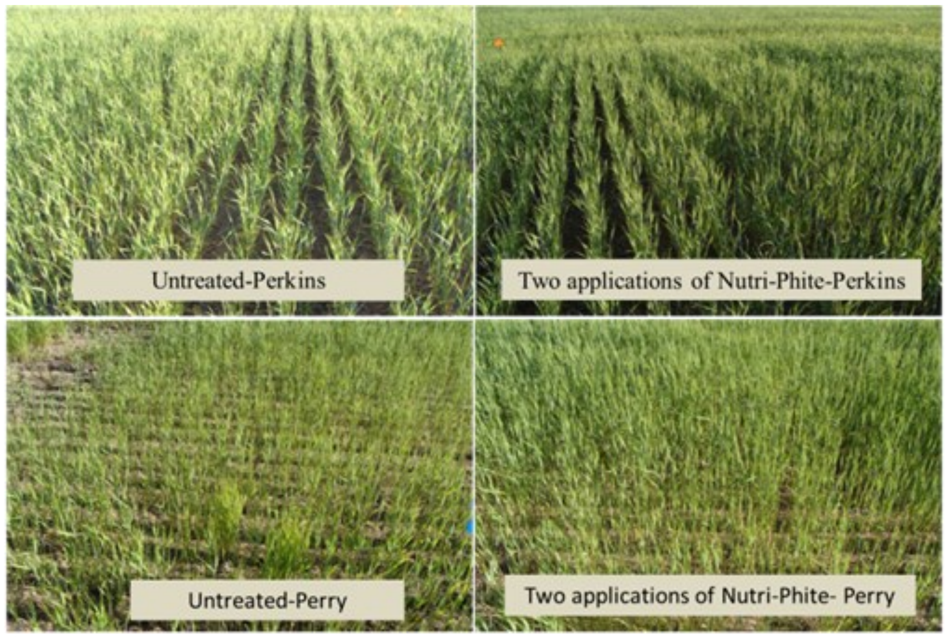
Ghimire, R., J.B. Norton, U. Norton, J.P. Ritten, P.D. Stahl, and J.M. Krall. 2013. Long-term farming systems research in the central High Plains. Renewable Agriculture and Food Systems 28:183-193.

Norton, J.B., E.J. Mukhwana, and U. Norton. 2012. Loss and recovery of soil organic carbon and nitrogen in a semiarid agroecosystem. Soil Sci Soc Am J 76:505-514.

FOLIAR NUTRI-PHITE MAY IMPROVE GRAIN YIELD AND P CONCENTRATION OF WINTER WHEAT

By Kefyalew Girma[1], Muaid S. Ali[2], Jeff Edwards[2], and Nigel M. Grech[3] – [1]Washington State University, [2]Oklahoma State University, Stillwater, OK, [3]Biagro Western Sales Inc., Visalia, CA

One of the major problems that potentially hinder the use of foliar fertilization as a tool for improving nutrient-use efficiency is the lack of effective formulations. A phosphite-based product called Nutri-Phite® was evaluated as an alternative formulation for foliar application in winter wheat (*Triticum eastivum* L.) at three sites (Perkins, Morrison and Perry, Oklahoma) during a two-year period (2009/10–2010/11). Nutri-Phite is a foliar fertilizer formulation developed to overcome problems associated with the absorption of phosphorus (P) through leaf tissue in an effort to improve nutrient-use efficiency, boost crop yield, and increase grain quality. Nutri-Phite contains phosphite (PO_3) and a blend of organic acids that stabilize and safens the phosphite molecule that the leaves of plants take up. This product has been used in many horticultural crops; however, it has not been tested in major cereals, such as wheat. In this article, we will present data that compare Nutri-Phite with and without soil-applied P along a check on grain yield and phosphorus concentration, and productive tillers. Nutri-Phite was applied at 2–4 leaf and/or booting to flowering stages of winter wheat at the rate of 4 L ha^{-1}. Treatments were (1) non-fertilized, and they included (2) Nutri-Phite at 2–4 leaf and booting/flowering stages (Nutri-Phite 2x) as well as (3) P applied at 100% sufficiency + Nutri-Phite at 2–4 leaf and booting to flowering stages (P 100% + Nutri-Phite 2x).



Pictures depicting crop vigor and greenness at Perkins and Perry, OK (Photos were taken 12 days after the second Nutri-Phite application on 5/8/2010).

The application of Nutri-Phite with or without pre-plant P produced more grain yield than did non-treated plots. Nutri-Phite alone produced 21%, 7%, and 71% more grain yield than did the non-treated plots at Perkins, Perry, and Morrison, respectively (Figure 1). The Nutri-Phite, combined with pre-plant P applied to reach 100% sufficiency, also resulted in 35%, 10%, and 71% more grain yield than did non-treated plots. However, the Nutri-Phite only and the Nutri-Phite with pre-plant P did not produce significantly different yields (Figure 1) in all locations.

Nutri-Phite 2x treatment resulted in greater grain P concentration compared with non-treated plots (22% more) at Perkins (Figure 2). This treatment resulted in 11% more grain P concentration than did the other sites (Perry and Morrison). The Nutri-Phite 2x treatment had 26%, 2%, and 7% more grain P concentration than did the P 100% + Nutri-Phite 2x treatment at Perkins, Perry, and Morrison, respectively.

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Foliar Nutri-Phite May Improve Grain Yield, cont. from pg 6

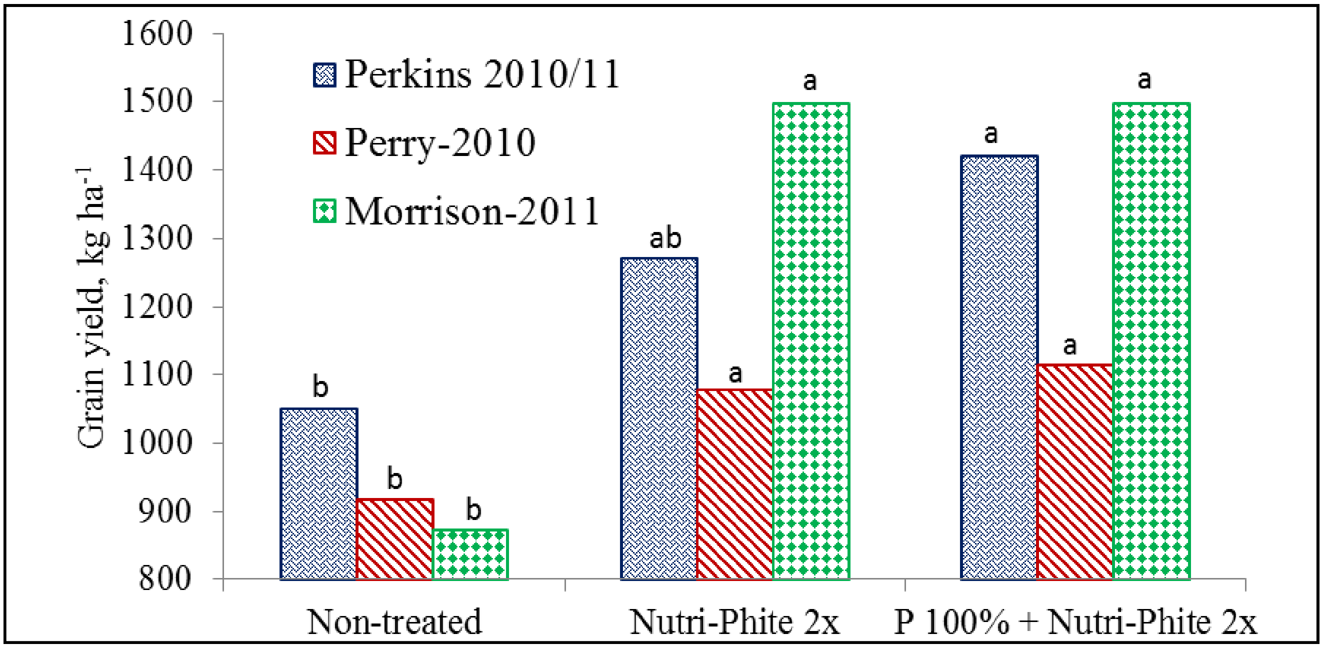

Figure 1. Winter wheat grin yield as influenced by treatments at Perkins, Perry and Morrison, Oklahoma in 2009/2010 - 2010/11. Within each site, bars followed by the same letter were not statistically different at $P \leq 0.05$ using Duncan's Multiple Range Test.

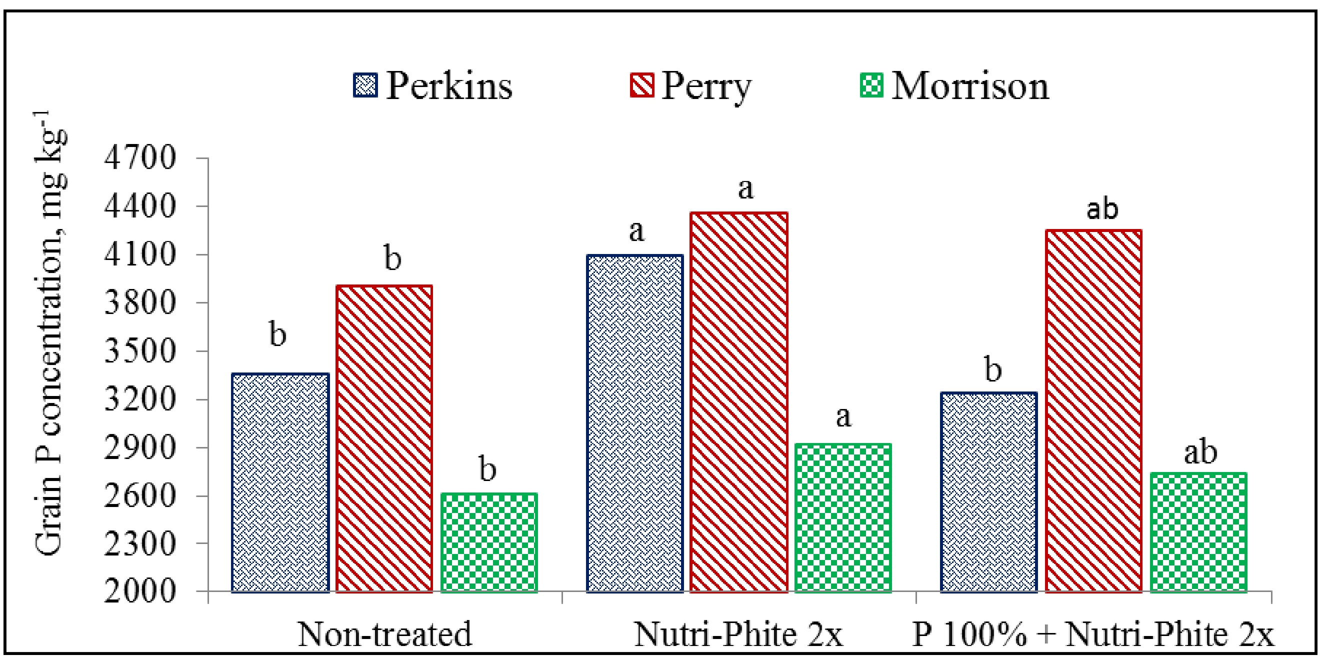

Figure 2. Winter wheat grain P concentration as influenced by nutria-Phite at Perkins, Perry and Morrison, 2009/2010-2010/11 winter what growing seasons. Within each site, bars followed by the same letter were not statistically different at $P \leq 0.05$ using Duncan's Multiple Range Test.

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Foliar Nutri-Phite May Improve Grain Yield, cont. from pg 7

At Perkins, the Nutri-Phite 2x and P 100% + Nutri-Phite 2x treatments resulted in 0.5 more tillers and 0.4 more tillers, respectively, than did non-treated plots. At Perry, Nutri-Phite 2x and P 100% + Nutri-Phite 2x treatments had 1 more tiller and 1.2 more tillers, respectively, than did non-treated plots (Figure 3). Results suggested the importance of both soil-applied P as well as a foliar supplement for increasing the number of tillers per plant. The number of tillers at Perkins and Perry was significantly correlated with grain yield (r=0.6, p<0.0001 and r=0.6, p<0.01, respectively). An increase in tiller number is associated with an increased yield.

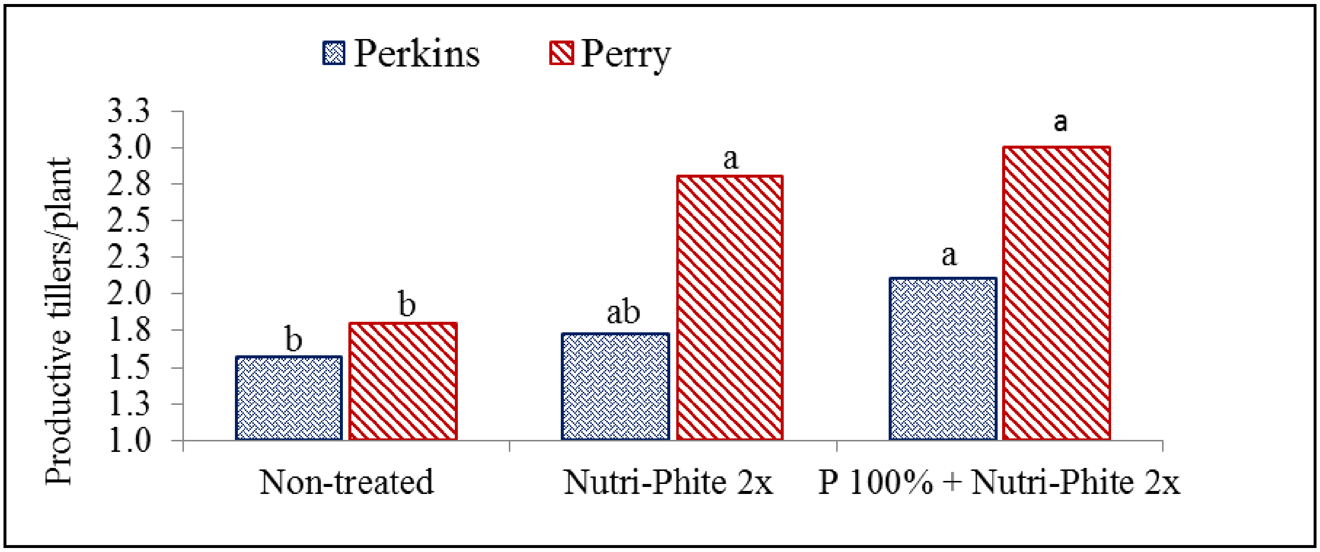

Figure 3. Winter wheat productive tiller number as influenced by treatments at Perkins and Perry in 2009/2010. Within each site, bars followed by the same letter were not statistically different at $P \leq 0.05$ using Duncan's Multiple Range Test.

In summary, Nutri-Phite with and without pre-plant P fertilizer at all fields did affect grain yield and P concentration as well as the number of productive tillers per winter wheat plant. Results suggested that Nutri-Phite had the potential for improving yield and the quality of winter wheat. The higher grain P concentration of plots that were treated with foliar Nutri-Phite clearly demonstrated its potential to improve the P status of wheat grain. These results are significant because P is an essential nutrient for a healthy life due to its role in bone and teeth formation and maintenance as well as in improved digestion, energy storage, and protein and hormone synthesis.

Selected References

Biagro Western. 2006. Nutriphite. [online] Available at http://www.biagro.com/Nutriphitei_phite/np_html .

Girma, Kefyalew, K. L. Martin, J. Mosali, K. W. Freeman, R. K. Teal, S. M. Moges, D. B. Arnall and W. R. Raun. 2007. Determination of optimum rate and growth stage for foliar applied phosphorus in corn. Commun. Soil Sci. Plant Anal. 38 (9&10):1137-1154.

Mosali, Jagadeesh , Kefyalew Desta (Girma) , Roger K. Teal , Kyle W. Freeman , Kent L. Martin , Jason W. Lawles, and William R. Raun. 2006. Effect of foliar application of phosphorus on winter wheat grain yield, phosphorus uptake, and use efficiency. J. Plant Nutr. 29:2147-2163.

Noack, S.R., T.M. McBeath, and M.J. McLaughlin. 2010. Potential for foliar phosphorus fertilization of dryland cereal crops: a review. *Crop and Pasture Sci.*61(8): 659- 669.