A producer can monitor input use efficiency by following the cost of production per bushel. Optimum input mix efficiency and maximum profit are associated with the position where **cost per bushel is minimized**. A producer is justified in adding further inputs as long as the cost per bushel continues downward in response. Optimum input mix is attained when inputs are added up to the point where **marginal cost equals marginal revenue** (the last dollar of input cost returns only one dollar in additional revenue).

Yes. Over the long run, a producer who is watching their input costs as noted in question 1 above, will be adding optimal input levels and avoiding excessive input levels or abusive practices which may prove harmful to the environment or to the long term productive potential of the soil. In addition, effective management of productive fields leaves other, less productive areas out of production and in alternative uses for which they are better suited (e.g. pasture, wildlife refuge, etc.). Example: efficient utilization of applied N fertilizer (as influenced by the timing and rate of application) also means low levels of nitrate leaching into the groundwater. In addition, other less productive acres which would require greater inputs per bushel produced, may then be left out of production.

**GPS** is an acronym for "Global Position Systems" and commonly refers to the use of satellites and differential correction using signals emanating from transmitting towers whose global position and altitude are known. **GIS** is an acronym for "Geographic Information Systems" and refers to the acquisition and spatial mapping of information referenced to accurate global position. **VRT** is an acronym for "Variable Rate Technology" and refers to the application of variable rates of a crop input as determined by accurately-mapped spatial data (such as change in soil type within a field).

**Example:** GPS may be used to determine the position of a combine as it moves through a field. GIS could include the monitoring and mapping of yield data relative to discrete positions within the field. VRT could be used to vary the amount of N applied site-specifically within the field to reflect differing historical yield levels.

**Soil type** (as denoted on soils maps and visually by color, texture, slope, drainage).

**Prior management** Records are used to indicate prior management differences within a field. These might include differences in yield, prior ownership, crop rotation, etc.

Once a field's yield and soil test level histories are established, areas of similarly productive soils with a history of equivalent soil test levels and yields can be consolidated for representative sampling as units or unique management zones).

**Sample to a depth of 8 inches for routine P and K fertilizer recommendations.**

a) 15 ppm

b) (15 ppm - 11 ppm) (5) = (4)(5) = 20 pounds P$_{205}$/acre

**Sample to a depth of 8 inches for routine P and K fertilizer recommendations.**

a) 75 + (2.5 X C.E.C.) = 75 + (2.5 X 13) = 75 + 32.5 = 107.5 ppm

b) (107.5 - 90) [1 + (0.05 X 13)] = (17.5) [1.65] = 28.9 pounds K$_{20}$/acre

At the Economic Goal (Critical Level) there remains a 10 to 40% probability of yield response to additional P and/or K fertilizer application. However, even though yield level
may climb (in some years) cost per bushel also begins to climb, reducing the profit level (over multiple years).

4 pts 9. Random symptom appearance within a field most probably indicates a biotic cause such as insect feeding or a disease (plants vary randomly in their exposure to the insect or disease.

Symptom appearance in a regular pattern most probably indicates an abiotic cause such as a mechanical problem (e.g. overlapping spray application producing a recurring pattern of carryover injury at intervals across a field).

7 pts 10. \((0.90)(0.85)(0.80) = 0.612\) or \(61.2\%\) surface residue cover.

10 pts 11. No-till systems will typically demonstrate higher bulk density (initial tillage lessens bulk density for the first few weeks of the season), lower temperature (insulating blanket of residue retains low soil temperature and residue reflects warming sunlight away), and higher moisture (less evaporative loss under residue means wetter, cooler conditions) near the surface (where young roots are forming) vs. a conventionally-tilled system. All of these factors result in less total root growth and a more shallow placement of root growth in the no-till system.

10 pts 12. Any factor which results in low soil temperature during germination and establishment can result in slow crop development and a reduction in crop yield potential. Such factors would include: heavy crop residue (e.g. corn), poor drainage, nearly level soils, and location at northern latitudes. Combinations of these factors can determine the fit or adaptation of a tillage system in a given environment (e.g. no-till is poorly adapted to poorly-drained soils in continuous corn at a northern location).

4 pts 13. a) Reduced yield
b) Decreased height
c) Delayed maturity
d) Tabled (horizontal) roots
e) Visible nutrient deficiency symptoms
f) Heightened drought stress
g) Increased sensitivity to herbicide injury
h) Slowed infiltration of water (surface ponding, evidence of poor drainage such as mottled color or slow crop residue decomposition)
i) High bulk density as reflected by resistance to soil probe or knife
j) Surface crusting indicates shallow compaction resulting from heavy rainfall
k) Seedling lateral roots restricted to seed slot (sidewall compaction).
4 pts 14. Prevention:
   a) Provide adequate drainage (install or repair surface and subsurface drainage).
   b) Stay off of wet fields.
   c) Reduce primary and secondary tillage where possible.
   d) Use lighter equipment or improved flotation tires on existing equipment (e.g. grain carts).
   e) Unload at field ends (and unload partial hoppers) when soils moist.

Correction:
   a) Deep tillage in dry years (shatter plow pan).
   b) Small grains and forages in rotation where practical.
   c) Natural freeze-thaw cycles are shallow and generally ineffective in lessening soil compaction in the root zone.
   d) Natural shrink-swell (seasonal dry / wet cycling), natural earthworm activity, and root growth will lessen deep compaction over time in soils where primary tillage has been reduced or eliminated.

5 pts 15.
   a) Shallow rooting and poor root uptake of mineral nutrition
   b) Increased soil compaction potential
   c) Delayed planting
   d) Delayed harvest
   e) Late-season drought stress
   f) Non-uniform herbicide incorporation
   g) Potential delay in field access for post-emergence herbicide application
   h) Greater N losses to denitrification

2 pts 16.
   a) Typical depth is 4 feet.

3 pts
   b) Depth of drainage to 48 inches promotes deep rooting and better season long access to nutrition and water. Surface drainage only would leave the root zone saturated with water for longer periods and reduce root development.

Subsurface drainage systems do not interfere with traffic during normal field operations as do surface drainage systems such as grassed waterways.

5 pts
   BONUS A soil "mottled" in the top 18 inches of its profile has both oxidized (rust-colored) iron and reduced (gray-colored) iron present. The gray (reduced) iron is evidence of prolonged water-logged conditions. This appearance in the top 13 to 18 inches indicates poor drainage critically-high in the root zone. Poor drainage is a likely restriction on yield in that environment.