Wear injury on sports fields: BMP approach

THE TERM "TRAFFIC STRESS" encompasses all types of stresses on sports turf resulting from both human and vehicle traffic. To develop sound management practices it is important to understand each individual type of traffic stress since they differ substantially as to mode of injury and management. The major types of traffic stresses are soil compaction and wear injury; but the focus of this article on wear injury.

Soil compaction, caused by traffic pressure on the soil matrix, results in a more compacted, dense soil mass, especially in the surface 3 inches, with few macropores for aeration, water infiltration, and root channels along with higher soil mechanical strength. These adverse soil physical conditions result in root and shoot deterioration over time.

Wear injury is the immediate, direct injury to shoot tissues by traffic action in the form of abrasion, pressure, scuffing, tearing, and/or divoting damage where pieces of turf and sod are displaced. Each sport imparts different mixes of these physical injuries. Moderate traffic may cause some discoloration and slight thinning of the turf over a period, while intensive traffic may result in immediate tearing of the sod and severe loss of stand density. Tissue damage from pressure, scuffing, or abrasion, may require one, or two, days to be apparent, while tearing and divoting actions result in immediate damage. Normally for pressure, scuffing, and abrasion wear, turfgrass takes a bruised (dark-green, moist) look, turning to blue-green wilted tissue before decreasing in greenness within 24-48 hours. Close leaf inspection may reveal shredding and/or wearing off of the leaves and even stems.

WHAT IS THE DOMINANT TRAFFIC STRESS?

Knowledge of the dominate traffic stress or stresses is important because practices to reduce direct physical injuries to plant shoot tissues (wear) will differ from addressing soil physical problems (soil compaction). For sports fields with fine-textured soils without a sand layer at the surface, soil compaction normally would be the dominant traffic stress, especially if clay/silt content is high, the clay type is shrink-swell clay, or surface and subsurface drainage is poor. However, wear stress will still be very evident on these fine-textured fields, so both stresses must be addressed in management protocols. On high sand-content (> 85 % sand), well-drained sports fields, wear injury are the most important traffic stress while soil compaction is of little importance. This would also be true for fine-textured soils that have received sufficient sand topdressing (usually 3.0 inches or more sand layer) and internal drainage to negate surface soil compaction.

BMPS TO PREVENT OR MINIMIZE WEAR INJURY

The best management practices (BMPs) term noted in the title highlights that management of wear stress, similar to other traffic, environmental, or pest stresses, requires a holistic, science-based approach where multiple management strategies must be combined together to achieve success. Essentially, a good BMPs wear management program will minimize the traffic factors, turfgrass characteristics, and soil conditions that favor a greater degree of wear injury with the turf manager selecting the "best" set of options that can be used for their specific site based on economic, field playability for the sport, environmental, and societal (i.e. player safety) considerations, i.e. a sustainable sports field management approach.

Traffic factors that increase wear are: a) repeated, concentrated traffic in an area; b) turning, twisting, or slipping traffic actions; and c) high pressure per unit area on the grass tissue and underlying soil. A well-designed traffic control plan supported by administrators, coaches, and field managers is essential to minimize unnecessary wear and soil compaction on athletic fields, i.e., to insure safe playing fields. Components of

Table. Traffic Control Measures to Reduce Wear on Sports Fields

- Develop a traffic control plan agreed to by administrators, coaches, and field managers. Determine who has authority to limit field use. Photos and documentation of traffic damage and stresses can aid in development and adjustments of plans.
- Games only fields – hold scrimmages and practices on practice fields
- Field rotation plan for practice fields
- Shift fields by > 100 feet from prior location
- Use N-S and E-W practice field layouts
- Use all field areas
- Consider spectator traffic patterns in the overall traffic plan
- Move goals weekly or as needed
- Coaches need to distribute drills as much as possible off of practice fields – this requires improved grass areas adjacent to fields
- Use different colored markings for different sports on multiuse fields
- Limit band practice on game fields to once per week and not when fields are too dry or too wet
- Develop yard lines for band practice in parking lots or improved grass areas other than practice and game fields
- Minimize extra-curricular use of fields – restrict use on dry of wet field conditions
- As much as possible limit traffic on excessively wet, dry, frozen or partially thawed turf – mowing should not be done on drought stressed grass
- Cover fields receiving short-term intensive traffic such as concerts
- Cover sideline area during games
- Allow only vehicles with of pneumatic "turf" tires will aid in reducing the pressure and tear components of wear

an overall plan are noted in the table.

The primary **turfgrass characteristics** that influence plant wear tolerance are: a) degree of living shoot biomass, i.e., verdure and shoot density; b) turfgrass growth rate; c) nature of the thatch or mat layer where both include living and dead organic matter; d) presence of high plant succulence or low cell turgidity; and e) nature of turfgrass rooting, stolon, and rhizome development. Turfgrass species and cultivars within a species that exhibit superior wear tolerance inherently have characteristics that foster better tolerance to wear.

Studies on turfgrass species or cultivar wear tolerance consistently demonstrate that greater wear tolerance is associated with high verdure and shoot density at the normal mowing height for a particular use. The first line of defense against wear injury is a dense, healthy turfgrass stand that provides a cushioning effect and ability to rapidly regenerate leaves and shoots. Attention should also be given to any factor that may limit growth rate or cause a decline in shoot density since slow growth and low density not only foster greater wear but delay recovery. Sometimes the active growing period can be extended somewhat in the fall or early spring by Fe and N applications.

Important factors affecting turfgrass growth rate are: a) nutrient limitations or deficiencies retarding growth—most common on sand-based fields would be low N, P, Mn and Mg (K will be discussed later), where soil tests and plant analysis will aid in determining needs; b) climatic conditions can limit growth and those that cannot be dealt with by direct management should be considered in traffic control measures (common are drought, cool/cold or excessively warm weather); c) saline conditions from saline irrigation water acts as a plant growth regulator; d) surface soil compaction inducing low soil oxygen and high mechanical strength can reduce shoot growth by 30-50 % which significantly increases potential for wear injury; e) sand fields where the organic matter accumulates to above approximately 4-5 % by dry weight in the surface 1-2 inches can result in low soil oxygen if the sod receives moisture daily by irrigation or rainy periods which in turn limits shoot and root growth; f) any pest limiting growth or reducing shoot density; g) scalping or mowing too close even if not a scalp condition; h) shaded grass has more fragile and spindly shoot tissues that are more susceptible to wear injury and the lower light limits recovery; and i) application of a PGR that excessively reduces plant growth rate during high traffic periods. PGRs often are used to "tightened up" the canopy which can aid in wear tolerance but delay recovery if wear injury occurs.

Thatch is a layer of live and dead plant tissues overlying the soil surface, while mat is a layer of living and dead organic matter with appreciable sand or soil intermixed. A "good" mat should have > 85 % sand by weight so as not to be dominated by the organic matter component. Mat layers that do not contain sufficient sand can result in a compacted organic layer that holds excessive moisture during wet periods and can result in poor rooting. Moderate thatch/mat (0.25

to 0.50 inch) reduces wear damage due to greater cushioning and provides better traction or footing compared to no thatch. Excessive thatch or mat without sufficient sand integrated into it greatly increases potential for tearing and divoting action and will have poor rooting stability. During dry periods on high-sand fields, excessive organic matter can also foster water repellant, hydrophobic areas where the grass is susceptible to greater wear damage and reduced root stability.

Excessive tissue succulence increases susceptibility to wear injury since tissues are more fragile due to less total cell solids (important factor in wear tolerance) but higher water content (by weight). Conditions fostering succulent grass are too high nitrogen, low light conditions, excessive irrigation, and poor surface or subsurface drainage where the grass is growing in excessive moisture.

Shoot tissue cells exhibiting low turgidity are much more susceptible to wear injury than plants under normal cell turgidity. Low cell turgidity results from lack of sufficient cell moisture to maintain a turgid cell wall that resists wear stresses where conditions contributing to low cell turgidity are: a) inadequate soil moisture; b) lack of a good root system to take up soil moisture during hot, low humidity periods; c) soil salinity from saline irrigation water inducing physiological drought stress on the plant; and d) inadequate potassium for osmotic adjustment of the plant to drought stress. Management practices to address situations that foster low cell turgidity are especially important during field use periods; and this includes avoiding mowing on a drought stressed field since this can cause considerable shoot tissue injury including death.

Adequate plant potassium deserves some attention since it contributes to total cell solids and maintenance of cell water for turgidity (rigid cells). For example, research on seashore paspalum under saline irrigation water has demonstrated that potassium is required for > 25% of cell turgidity (osmotic adjustment) and cannot be substituted for by another cation or organic osmolyte. Potassium deficiency also causes stomata to remain open in grasses with high water loss and reduction of cell turgidity. Typically, higher potassium rates are recommended for recreational sites compared to general turfgrass areas. On all but high sand-content, root-zone media, soil testing is the best method of determining potassium needs with a target range within the upper medium range for extractable potassium.

On irrigated sand fields, potassium can be easily leached making it difficult to maintain soil test values. Losses also occur if clippings are removed. However, too much potassium can increase soluble soil salt levels during prolonged dry periods without any leaching losses, and reduce water uptake. For high-sand, irrigated, recreational turfgrass sites, many research scientists (including the author) suggest that potassium fertilization rates be coupled with nitrogen application rates and timing with the following suggestions for recreational grasses when the irrigation water is not saline: a) < 6 lb N per 1000 ft2 per year, use a 1:1 N: K20 ratio; b) > 6 lb N, use a 1:0.75 N:K20 ratio. During rainy periods when soil K may leach, foliar application aids in maintaining adequate shoot tissue K and cell turgidity. If the irrigation water is saline, especially when sodium is moderate or higher, a higher N:K20 ratio such as 1:1.5 may be necessary along with periodic foliar K application. Applications of K based on N rates are *only* for heavily leached sand media. Unfortunately, many turf managers with K-retaining fine-textured soils have used the "ratio method" (ignoring soil tests) resulting in excessive K applications and promoting build-up of K (a salt) within the soil especially in prolonged dry periods.

The nature of the grass species and cultivars within a species influence the wear tolerance of the grass. Characteristics that enhance wear tolerance are: a) high inherent shoot density coupled with an adequate shoot growth rate; b) strong and deep rooting grasses that resist tearing actions; c) grasses with good lateral stolon/rhizome growth; and d) a grass that is adapted to the climatic and pest stresses and mowing regime at the site so that it can maintain good growth. Wear tolerance differs from soil compaction tolerance so results from studies should be evaluated for what mix of traffic stresses were actually present in the study. Over the past 10 years several research scientists have evaluated relative wear tolerance and mechanisms (physiological, morphological, and anatomical plant differences) that contribute to superior wear tolerance of a cultivar within a species, which can vary considerably from the general ranking for a species.

Turfgrass species and cultivars of a species vary not only in wear tolerance but also wear recovery. Plant aspects influencing rapid recuperative potential include: high inherent growth rates; presence of lateral stolons and/or rhizomes; and physiological health of the plant, especially carbohydrate reserve levels.

During the winter several types of wear injuries can occur: wear on dormant tissues; traffic on frosted green leaf tissues (disrupting brittle protoplasm); and traffic on thawed surfaces where the underlying soil remains frozen.

During the winter several types of wear injuries can occur: wear on dormant tissues; traffic on frosted green leaf tissues (disrupting brittle protoplasm); and traffic on thawed surfaces where the underlying soil remains frozen. Traffic on dormant tissues causes considerable wear since there are no live green leaves to cushion the pressure and no regrowth. Dormant warm-season grasses overseeded with a cool-season species can tolerate more traffic as the overseeded grass provides a protective cover and cushioning. However, the primary grass may decline over time from overseeding competition.

SOIL FACTORS

Soil texture has a strong influence on different types of wear as well as proneness to soil compaction. Sandy, well-drained soils, while resistant to soil compaction and less prone to water-logging than fine-textured soils, are more susceptible to being droughty that requires careful irrigation to avoid drought stress during field use. High-sand content fields at field capacity have better traction and stability to resist tearing action and divoting than when drier. If the irrigation water is saline, sandy soils compared to fine-textured soils will exhibit: more rapid accumulation of total soluble salt; much less susceptibility to soil structure deterioration by sodium; and are much easier to leach salts. Sand provide greater friction, especially when wet, than a heavier soil; however, fine-textured soils provide more root stability against divoting or tearing. A mat layer of 0.25 to 0.50 inch on a sand field will aid root stability. Careful selection of the sand used for construction and topdressing is important so as not to use a well-rounded sand shape, especially if the particle size range in narrow, since the sand may not stabilize; thereby, resulting in susceptible to divoting and tearing. Whether a sand or fine-textured field, accumulation of excessive surface organic matter should be avoided to minimize divot, tear, and slippage actions—and on a sand field may enhance development of hydrophobic areas.

Any soil factor that leads to excessive soil moisture at the surface will increase wear injury and divoting. Common situations fostering excessive surface moisture are: a) low inherent water infiltration and percolation rates typical of many fine-textured soil types; b) compacted soil surface; c) poor surface drainage where water collects in depressions within field areas; d) any subsurface layer that impedes water drainage. These conditions are primarily on fine-textured soils and remediation practices include combinations of good surface and subsurface cultivation programs, surface drainage by proper contouring, tile drainage, sand-slitting, and sand-capping directly or over time by topdressing with sand.

Topdressing is important on both sand and fine-textured sports fields to enhance wear tolerance. On sand fields, topdressing can control the nature of the surface organic matter by producing a good mat that integrates into the underlying soil and is a good rooting media. For fine-textured soils, especially those prone to soil compaction and with poor drainage, topdressing is essential to build up a surface high-sand layer (ideally of > 3.0 inch) so that the surface does not compact nor easily waterlog. Heavy topdressing should be avoided during high use periods since it leaves considerable sand around the upper crown and stem tissues which, combined with the brushing and drag-matting needed for integration causes considerable abrasive wear. Fewer problems are apparent with lighter, more frequent dressings.

A key distinction of recreational turfgrasses compared to other turf sites is the traffic stresses on these living entities. Wear stress can be in various forms from abrasion, scuffing, tearing, pressure, and divoting depending on nature of the traffic. There is no silver bullet in management of wear stress, rather success depends on using a holistic, BMP approach that includes traffic control measures, fostering plant conditions to maximize wear tolerance and recovery, and addressing any soil factors that impact the degree of wear stress. Successful maintenance of traffic stresses (wear and soil compaction) ultimately impact the athlete's performance and safety via footing, traction, and stability.

Dr. Robert N. Carrow is with the Crop & Soil Sciences Department, University of Georgia/Griffin Campus. ■