Flood Recovery: What we've learned in Australia and Thailand

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FLOODS IN AUSTRALIA

Isolated flooding started across parts of Queensland in early December 2010, which was the state's wettest December on record. With the ground already saturated and following heavy rainfall in the upper catchment of the Brisbane River and its tributaries, flooding in the city of Brisbane began on 11 January 2011 and peaked on 13 January. The clean-up began on 17 January but the timing of clean-up varied depending on the means (i.e. manual or mechanical), the resources available (money and personnel) and management was on-going for several months as turfed areas recovered or were replaced. While manual clean-up with high pressure hoses was possible as soon as the floodwaters had dissipated, mechanical operations were not possible for 2-3 weeks after the flood (including more significant rainfall) when the ground had firmed up sufficiently to carry machinery.

Over the next few months, this pattern of flooding and recovery was repeated in many other towns throughout Queensland as the seasonal deluge continued under the influence of an intense La Niña rainfall pattern, which brings wetter than average conditions to eastern Australia (Bureau of Meteorology, 2012). More than half of the state was affected by flooding at some time during the 2010/11 wet season, in some cases multiple times: the golf course in the southern Queensland town of Dalby, for example, was flooded eight times during this period.

In Queensland most of the turf damage was attributed to the impact of the silt deposits on the turf.

FLOODS IN BANGKOK

With heavy monsoon rains, floods and mudslides starting in late July 2011, Thailand faced the worst floods in the past 50 years. With much of Thailand's river system draining to the south into the Chao Phraya River Basin there was a dramatic southward progression of flood waters from the central provinces of Thailand towards the capital city of Bangkok. By mid-October, flood waters had expanded considerably in total area, effectively surrounding downtown Bangkok, while severely affecting most outlining populated areas. The flood waters did not begin to recede until late November. The north, northeast and central plains of Thailand were the worst areas affected.

The flooding affected about 18 golf courses to the north and north east of central Bangkok with many of them under water for up to 8 weeks. The golf courses were affected in different ways, however, most were under water for at least 4 weeks and as long as 8 weeks. The depth of the water and the time under water had the greatest effect on the survival of the particular turfgrass species. There were considerable differences in the survival rate between Bermudagrass, Zoysia and Seashore Paspalum.

FLOOD IMPACTS ON GOLF COURSES

As we have observed, the effects of floods are many fold including deep silt deposits, loss of turf, erosion and the associated longer term turf management challenges. To observe the damage and loss of amenity is very disheartening to someone that has many years' experience working in the sportsturf industry. The magnitude of the challenges, particularly for the lesser resourced golf clubs, is at times quite overwhelming.

Every golf course provided a different story and a different set of circumstances that determined the extent of the damage. As an agronomist the interesting aspect was the effects on the different grass species. While we can read the results of rigorous research it is not until you see the grasses under adverse conditions in the field that you can truly understand the strengths and weaknesses of different turfgrass species but also understand the complexities of floods and the multitude of factors that affect the turf. Damage to turfgrasses affected by floods is due to several factors including; silt deposits, turf species, drainage, depth of the flood waters and the length of time that the turf is inundated.

In Australia silt deposits was the cause of most turf damage whereas in Thailand it was more to do with the depth and time of inundation.

SILT DEPOSITS

The enduring memory for those involved in cleaning up turf surfaces after the flood is the amount of silt deposited and how to remove it. The depth of silt varied from a film up to a centimetre or two thick through to deposits greater than 30 cm thick over the turf. Mostly, the deposits were quite fine-textured, interspersed with patches of coarse sand where floodwaters had been faster moving.

Samples of fine silt were collected and analysed and these had reasonable levels of most nutrients with the notable exception of N, and were mildly alkaline, with moderate salinity levels that would have no effect on most plants. The limitations of the silt related particularly to its physical status with 75% of fine clay and silt, 24% fine sand and just 1% coarse sand. When wet, it was exceedingly sticky and slippery to walk on; when dry, it became extremely hard and impermeable, lacking any semblance of good soil structure, and cracking into large blocks. Cleaning the silt off as quickly as possible was a key aspect to recovery.

The silt has continued to provide some challenges with fine layers deposited in sand profiles, significantly restricting infiltration rates. Where these layers were not broken up it only takes a few millimetres of rainfall or irrigation to make the surface muddy and slippery. The silt layers have also been responsible for restricting root growth and recovery and various root diseases.

A key management aspect to recovery has been hollow tining and sanding and on-going spiking to continue to break through any layers. Scarifying has also been very effective in breaking up these layers.

TURFGRASS TOLERANCE TO FLOODING

In examining the tolerance of turfgrasses to prolonged flooding, irrespective of the other factors associated with floods, Zoysiagrass (Zoysia sp.) was the worst affected and the Bermudagrass hybrids (Cynodon dactylon x Cynodon transvaalensis) the least affected. Seashore Paspalum (Paspalum vaginatum) is another prominent species used in Thailand and depending on the depth of the flood waters was also severely damaged. Axonopus sp. (Carpetgrass, Cowgrass) was also severely damaged on Australian golf courses, however, it has proven to be an invasive weed species as it germinates from seeds in the soil and thatch.

Zoysiagrass is a native grass common to SE Asia and is extensively cultivated on greens, tees and fairways and can be quite invasive in other turfgrass species. It is a strong, resilient grass that has excellent drought tolerance, it is hard wearing and can be a challenge to mow. The research of Fry (1991), indicated that Zoysia had intermediate tolerance to submersion and would survive 55 days of submersion with minimal damage. Unfortunately in the field Zoysia has proven to have little resistance to flooding and most of the Zoysia observed on flooded golf courses was dead with no signs of recovery. The possible key aspect affecting the grass compared to the research data is the depth of the flooding. In the work of Fry (1991), the turf species were subjected to about 130mm submersion depth compared to at least 1000mm on the flooded golf courses. What these observations and thoughts raise is that the research gives us a starting point, however, the peculiarities of golf courses and the variables that a flood present can result in unexpected outcomes. Golf courses that were predominantly Zoysia were either overplanting with Bermudagrass and Seashore Paspalum or promoting the native Bermudagrass and native Seashore Paspalum that was regenerating.

Seashore Paspalum (Paspalum vaginatum) has recently become a popular grass on golf courses in Thailand because of its striking appearance and the ability to stripe it up like cool-season grass fairways. The references on the tolerance of this species to inundation are a little contradictory and confusing. Seashore Paspalum prefers moist to saturated sites and can withstand brief inundations (including by seawater), however, prolonged flooding is detrimental (http://plants.usda.gov/factsheet/pdf/fs_pava.pdf). Other references quoted by Duncan and Carrow (1999) suggest that Seashore Paspalum is most tolerant of waterlogged conditions on poorly drained sites. There has been a misconception that while Seashore Paspalum can withstand short periods of inundation it cannot tolerate long term flooding. On the flooded golf courses, Seashore Paspalum was severely damaged depending on the depth of the water. On one particular tee that was underwater for 8 weeks, but where the water depth was about 300mm, the damage was minimal and complete turf recovery was expected. With very little or sporadic recovery most Seashore Paspalum golf courses were undertaking extensive replanting. Interestingly, native Seashore Paspalum was widely evident and growing strongly on many golf courses that were previously Zoysia.

Interestingly, one of the oldest introduced grasses used on Thai golf courses is Bermudagrass, with Tifdwarf on greens and Tifton 419 on fairways and was the least affected by the flood and the recovery has been quite remarkable. Fry (1991), ranked native Bermudagrass as one of the most submersion tolerant species and this is consistent with Beard's (1973) observation that it has excellent submersion tolerance. The field assessments are consistent with these observations and given the damage to the other turfgrass species it is substantially superior in this aspect.

Where there was severe turf damage and no recovery, the roots, rhizomes and stolons were rotten and there was living tissue.

The other intriguing aspect of the floods was the effects of the depth of the water and the time the course remained flooded. The depth of water was particularly fascinating. Where the water was less than 0.5 metre, irrespective of the time the turf was under water, the turf in many cases (other than zoysia) was relatively unaffected. As the depth of the water increased, the greater the turf damage, irrespective of the turf type. There was one golf course that was under water for about 4 weeks and there was very little damage on the Bermudagrass anywhere on the golf course.

The effects of flooding are multifaceted with; the age of turf, age of the soil profile, surface topography and irrigation all being factors that affected turf damage and recovery. It is interesting to note that on a Bermudagrass green that had only been open for a week before the flood, suffered almost no damage compared to older and more established greens. On other greens where turf had been used to repair areas prior to the floods, the turf sod was the only surviving grass. On close examination there were two possible explanations; firstly the new green had no organic matter accumulation and once the water had receded the root zone could dry out very quickly and become well aerated. The other likely aspect is the more vigorous root system that develops under new turf and possibly the stronger network of rhizomes and stolons associated with the turf sod. The age and the drainage rate of the profile also has an influence, where the profile had a low organic matter content and the drainage rate was adequate the damage appeared to have been less.

It was noticeable on most golf courses that the lower sections of greens and fairways were the worst areas affected. Most of these lower areas were typically points for surface drainage and were therefore subjected to longer periods of saturated soils. It is also likely that there was some scorching due to icreasing water temperatures as the water became very shallow. The final factor that killed grass on greens, tees and fairways was moisture stress. While there were areas of turf that survived, the root systems were compromised with very few live, healthy roots. With many golf courses being sand capped they dried out very quickly once the water was pumped out. Because the irrigation systems were damaged, drought stress was a common problem across all the affected golf courses.

WEEDS

Flooding in Queensland was very effective in killing out several weed species and unwanted grasses such as Axonopus sp. and Queensland Blue Couch (Digitaria didactyla). However, all the flooded golf courses suffered from weed invasion, with weeds often being the first plants to appear.

Weed control remained an on-going issue for most turf venues and even sod production farms due to weed seeds carried in by the floods, including sedges (Cyperus spp.) and a number of difficult-to-control grass species, both perennial (e.g. Chloris gayana Kunth, Eragrostis tenuifolia (A.Rich.) Steud.) and annual (e.g. Digitaria ciliaris (Retz.) Koeler., Eleusine indica (L.) Gaertn.).

MANAGEMENT FACTORS AFFECTING TURFGRASS RECOVERY

There were several key factors that assisted in minimising turf damage and improving the chance of recovery;

i. **Silt removal:** How quickly the silt/mud was removed from the turf. Golf courses that removed the silt as the waters subsided appeared to have experienced less damage.

ii. **Renovation of turf areas:** Renovation of all turf areas including greens, tees and fairways as soon as they had dried out assisted in recovery. Hollow coring in particular appears to have been the most effective technique. Coring allows oxygen back into the soil and assists in breaking up the silt layer.

iii. **Irrigation:** Keeping adequate water up to the recovering turf was essential. All the flooded turf had a weak root system and quickly dried out when the water was pumped out of the course. Those courses that were able to affect quick repairs to the irrigation system or were able to link into a temporary water supply (e.g. tanker) experienced the least set back to the turf.

iv. **Planting dead areas:** Making an early decision on the likelihood that the turf will recover or not allowed many clubs to make a decision on whether overplanting was required and the extent of the overplanting. As a general rule any area that did not exhibit new growth within 2 – 3 weeks required overplanting.

v. **Weed control:** Weed control is key component of assisting in the recovery of the turf. Early control to reduce competition has assisted in the process of turf recovery.

vi. **Mowing heights:** Increasing mowing heights has assisted in the recovery of the turf. On greens an initial cutting height of about 8mm has allowed the root systems to recover. Once the turf has recovered the mowing height can be gradually reduced to about 4 – 5mm.

vii. **Insect control:** As soon as insects were identified they were quickly treated and controlled. This has ensured that there is no setback to turf recovery.

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