1. Plant nutrients and stress resistance

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The Turfgrass Research Group

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From the research project 2014 – 2017:
Optimal Application of Nitrogen and Sulphur in Autumn for Better Winter Survival of Perennial Grasses – With Emphasis on Turf

Norwegian Greenkeepers Association

Norwegian Golf Course Owners

Tapiola GC, Finland

Kungliga Drottningholm GC, Sverige

Hauger GC, Norway

Keilir GC, Iceland

Roskilde GC, Denmark
Outline:

1. Plant energy and nitrogen levels
2. Nitrogen and disease resistance
   1. Anthracnose
   2. Red thread
   3. Dollar spot
   4. Take all patches
3. Rhizosphere and fertilization
4. Autumn fertilization and snow mould
Comments to the «ideal» fertilizer

All numbers are related to the N level. N is the minimum factor in this recipe and will control the growth rate.

The need for Ca is low. Most plants contain much more than this. (“Luxury uptake” that cause problems for plants with perennial leaves, like Rhododendron)

Uptake of Mn (and Zn) is negatively related to soil pH, and extra applications should be considered when pH is extreme.

Grass growth CAPACITY and nitrogen status

Growth

N concentration in leaves

Agrostis stolonifera

Festuca rubra

Max

Max
Carbon allocation and n-rates

Relative root growth
Content of carbohydrates

The N-flux has impact on the carbohydrate content in the plants, and the carbohydrates are the energy source that can be used to resist stress situations.
Greenkeepers are «carbohydrate managers».

Plant stress can be defined as energy depletion.

Sugar from photosynthesis is the only energy source for the plants.
Sugar is used for all processes in the plants (flowering and seed production are not mentioned here). 1-4 in order of priority:

1. Uptake and transport of nutrients and metabolites
2. Defence
3. Symbiosis
4. Root exudates
Growth and respiration are related to environmental factors. Greenkeepers can to some extent control the N-flow.

Dry matter production and root/shoot ratio are strongly related to N-level.

Growth and respiration are related to environmental factors. Greenkeepers can to some extent control the N-flow.

1. Uptake and transport of nutrients and metabolites
2. Defence
3. Symbiosis
4. Root exudates
Factors that reduce/influence on the plant’s growth capacity:

- Wind
- Diffusion from soil
- CO₂
- H₂O
- Drought
- Dry spots
- Shallow roots
  - Compaction
  - Diseases
  - Oxygen depletion

By controlling (reducing) the N-rate, the greenkeeper can avoid plant stress caused by unfavourable growth conditions and keep the plants alive.

Reduce N-level

Function of temperature

1. Uptake and transport of nutrients and metabolites
2. Defence
3. Symbiosis
4. Root exudates
Finding the optimal fertilization rate is a delicate and difficult balance

- **Risk of energy shortage**
- **Need for growth to compensate for wear & damage & disease?**
Nitrogen and turf grass diseases

Reduced by increased N

– Antrachnose (*Colletotrichum graminicola*)
– Red thread / pink patch (*Laetisaria fuciformis* & *Limnomyces roseipellis*)
– Take all patch (*Gaeumannomyces graminis*)
– Dollar spot (*Sclerotinia homoeocarpa*)

Stimulated by high N rate?

– Pink snow mould / microdochium patches (*Microdochium nivale*)
Antrachnose (*Colletotrichum graminicola*)

**Disease fact**

Can attack several plants but typically annual meadow-grass (*Poa annua*) in summer stress situations.

Recommendation: Increased mowing height (top-dressing) and nitrogen rates.

Photo: T. Espevig
Red thread /pink patch

*Laetisaria fuciformis & Limnomyces roseipellis*

More common on fairways than greens. Attacks red fescue (*Festuca rubra*) and ryegrass (*Lolium perenne*)

Minor problem for playing quality.

Disappears usually when N-status is increased.
Dollar spot (*Sclerotinia homoeocarpa*)

**Disease fact**
- New disease in Scandinavia
- Attacks several grass species when weather is warm.
- Most commonly starting in for-greens / fairways
- Spread with infected grass/thatch!
- Symptoms reduced with frequent irrigation and increased N rates. Rolling greens may help.

Photos: Karin Normann
Take all disease *Geaumannomyces graminis* is related to soil nutrients

- Fungi reduce root function.
- Severity reduced if
  - pH < 6.2
  - Application of manganese (Mn) (2.5 kg Mn /ha every year)
- Symptoms are reduced by frequent irrigation and increased fertilization level.
Microdochium patch /pink snow mould (Microdochium nivale) and N-levels?

Effect of different fertilization levels (N) Landvik 7 October 2014
Autumn application of fertilizers

Background:

– Tradition of high potassium (K) and iron (Fe) applications

– American way: «Late fall fertilization» with nitrogen

– Research project 2008-2010 with late fall fertilization (20 kg N/ha) on 18 Nordic golf courses. Mainly positive results.

– Environmentally acceptable to use nitrogen in the late autumn?

Autumn fertilization practice 2015.

Results from NGF/STERF/NIBIO survey Winter Injuries on Nordic golf courses.

Last nitrogen application

- August
- Sept
- Before frost

DAN (36)  FIN (18)  ICE (22)  NOR (51)  SWE (97)
Additional potassium or iron

% of population taking additional potassium or iron supplements.

- **DAN (36)**: 40% (Potassium), 60% (Iron)
- **FIN (18)**: 30% (Potassium), 70% (Iron)
- **ICE (22)**: 5% (Potassium), 95% (Iron)
- **NOR (51)**: 20% (Potassium), 80% (Iron)
- **SWE (97)**: 30% (Potassium), 70% (Iron)

*Note: The numbers in parentheses indicate the percentage of the population taking additional supplements.*
NGF/STERF/NRC/NGA/FNG project: Optimal application of nitrogen and sulfur in autumn for better winter survival of perennial grasses – with emphasis on turf

Short name: AUTUMN APPLICATIONS

– Parallel field experiments at NIBIO Landvik and NIBIO Apelsvoll.

– Landvik: on a lysimeter for nitrogen leakage analyses

– Apelsvoll: half the green in shade
Experiment over two winters 2014-2016

Two grass species:

– Creeping bent (CB) (*Agrostis stolonifera*)

– Annual meadow-grass (AMG) (*Poa annua*)

*Established every year by the end of June. CB ‘Independence’ seeded 7g/m2. AMG established from 8 kg hollowcore plugs from Borregaard GC, Sarpsborg (50 year old *Poa* green)*
Fertilizer treatments:

<table>
<thead>
<tr>
<th>Treatment</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>Mg</th>
<th>Ca</th>
<th>S</th>
<th>Fe</th>
<th>Mn</th>
<th>Zn</th>
<th>Cu</th>
<th>Mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No N</td>
<td>0.00</td>
<td>0.16</td>
<td>0.76</td>
<td>0.08</td>
<td>0.09</td>
<td>0.11</td>
<td>0.011</td>
<td>0.0043</td>
<td>0.0023</td>
<td>0.0005</td>
<td>0.00036</td>
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<tr>
<td>2. Low N</td>
<td>0.40</td>
<td>0.16</td>
<td>0.77</td>
<td>0.08</td>
<td>0.09</td>
<td>0.14</td>
<td>0.011</td>
<td>0.0043</td>
<td>0.0023</td>
<td>0.0005</td>
<td>0.00036</td>
</tr>
<tr>
<td>3. Med N</td>
<td>0.80</td>
<td>0.16</td>
<td>0.77</td>
<td>0.08</td>
<td>0.09</td>
<td>0.14</td>
<td>0.011</td>
<td>0.0043</td>
<td>0.0023</td>
<td>0.0005</td>
<td>0.00036</td>
</tr>
<tr>
<td>4. High N</td>
<td>1.20</td>
<td>0.16</td>
<td>0.77</td>
<td>0.08</td>
<td>0.09</td>
<td>0.14</td>
<td>0.011</td>
<td>0.0043</td>
<td>0.0023</td>
<td>0.0005</td>
<td>0.00036</td>
</tr>
<tr>
<td>5. No S</td>
<td>0.80</td>
<td>0.16</td>
<td>0.77</td>
<td>0.08</td>
<td>0.09</td>
<td>0.00</td>
<td>0.011</td>
<td>0.0043</td>
<td>0.0023</td>
<td>0.0005</td>
<td>0.00036</td>
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<tr>
<td>6. High S</td>
<td>0.80</td>
<td>0.16</td>
<td>0.78</td>
<td>0.08</td>
<td>0.09</td>
<td>1.27</td>
<td>0.011</td>
<td>0.0043</td>
<td>0.0023</td>
<td>0.0005</td>
<td>0.00036</td>
</tr>
</tbody>
</table>

«Home made» nutrient mix. The rates of other nutrients were sufficient even at the high N content fertilizer. Differences marked in red letter.
Experiment treatments in project Autumn application of fertilizer: Weekly application of fluid fertilizer at declining rates in the period when air temperature was expected to decrease 12-1 °C

Autumn fertilization

P.annua & A.stolonifera

12°C
10 September

1°C
3 December

Kg N/100 m² per week

37 38 39 40 41 42 43 44 45 46 47 48 49
Overview of the AUTUMN APPLICATION experiments

Factors tested at both locations:
- Species
- N-level
- S-level

WP 1-2 (2014-2016)
Field experiment on lysimeter.
N-leakage

WP 3-4 (2014-2016)
Lab tests:
1. Resistance to M.nivale
2. Freezing resistance
3. Resistance to suffocation

WP6 (2016-2017)
Full scale demonstration trials at golf courses based on results from the scientific experiment
New data from this research project will be marked without other references.
Sulphur / Sulphate in the autumn?
We have seen recommended usage of

– Ammonium sulphate
– Iron sulfate
– Manganese sulfate
– Calcium sulfate

Brauen et al. The effects of Sulphur in combinations with Nitrogen, Phosphorus and Potassium on colour and Fusarium Path disease of Agrostis butting green turf. Washington St Univ. Proj. 1538
Can sulphate reduce snow mold?

1. Arena (control)
2. Arena + 1x GoGreen
3. Ammoniumsulfat + Arena Høst Extra
4. Arena + 2x GoGreen
Normal N
S as sulphate
S = 0
S:N = 1.6
(8.4 g/m² in autumn)
No effect of sulfate in field at Landvik

Field observations of disease (% spots) at Landvik

<table>
<thead>
<tr>
<th>Species</th>
<th>Treatment</th>
<th>2014 Autumn</th>
<th>2015 Spring</th>
<th>2015 Autumn</th>
<th>2016 Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. stolonifera</td>
<td>No SO₄</td>
<td>1.1</td>
<td>2.5</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td>A. stolonifera</td>
<td>Excessive SO₄</td>
<td>1.0</td>
<td>2.8</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td>P. annua</td>
<td>No SO₄</td>
<td>14.2</td>
<td>57.9</td>
<td>0.1</td>
<td>1.8*</td>
</tr>
<tr>
<td>P. annua</td>
<td>Excessive SO₄</td>
<td>12.0</td>
<td>62.1</td>
<td>0.1</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Number of observations
10 2 13 1

*one of three plots had 3% disease
Effects of fertilization levels on Microdochium patches and pink snow mould (both caused by M.nivale)

Results on next picture
NEWS from Autumn application

First year, no fungicide

Disease A. stolonifera Landvik

Second year, 1 kg/ha Delaro 31st Sept

Disease A. stolonifera Landvik

Disease P. annua Landvik

Disease P. annua Landvik

NEWS from Autumn application

First year, no fungicide

Disease A. stolonifera Landvik

Second year, 1 kg/ha Delaro 31st Sept

Disease A. stolonifera Landvik

Disease P. annua Landvik

Disease P. annua Landvik
Conclusion

High rates of fertilizer (nitrogen) in the autumn increase the risk of Microdochium patches in the autumn and pink snow mould in the spring.