SEED: PRODUCTION, STORAGE, SPECIFICATION AND SOWING

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ABSTRACT

Turf seed at the point of sowing has undergone a long journey from breeding, four generations of seed multiplication of high grade and commercial seed production, field inspections for quality assurance, seed cleaning, seed testing, warehousing and transport to end users. In the New Zealand seed industry the production of seed is associated with providing work to New Zealanders, farmers, harvesters, seed cleaners, straw balers and various contractors. New Zealand is the world's third biggest producer of ryegrass seed and has a reputation for producing quality. Quality seed for the turf industry is the result of attention to detail in seed production to ensure high physical and genetic purity, high germination and high endophyte levels. Maintaining genetic purity is a significant issue in perennial ryegrass, where hybridization for forage perennial and annual ryegrass occurs readily. Seed Certification Schemes are designed to protect genetic purity. Uncertified seed has an increased risk of being genetically contaminated from forage species of the same or related species.

Weed seed contamination, even at levels that are acceptable in Seed Certification can be an issue for high quality because of the high sowing rates used in turf, typically 10 times that used for forage sowings. Traces of cocksfoot, bromes or poa seed result in unattractive turf. Developing appropriate weed control practices especially herbicide mixes to control these species in turf seed crops have been very important task for seed production agronomists.

Seed viability declines over time, typically starting to decline after 24 months, depending on storage conditions. Endophytes decline more rapidly than seed germination. Turf managers need to understand seed storage issues especially if they purchase and store seed before sowing.

KEYWORDS

Turf seed, seed production, quality assurance, sowing, endophyte.

1 INTRODUCTION

Seed is the delivery vehicle for plant technologies. It typically takes 12-15 years of intensive breeding and evaluation from the concept of a new plant breeding program through to the establishment of a professional turf field.

Plant breeding involves many generations of crosses and reselections within a species in order to achieve the desirable traits that are stable in successive seed increases. Additionally, new turf ryegrasses and tall fescues also contain selected strains of fungal endophyte which can be reselected in conjunction with the plant breeding program. The endophytic fungi protects its host plant by deterring feeding from insects, birds and animals and providing tolerance to environmental stresses such as drought. Endophytes grow within the host plant into the developing seed and when the seed

is sown, they develop with the new grass seedling (Pyke et al., 2010), given that the seeds have not been exposed to conditions that were detrimental to the living fungi.

After about 8 – 10 years the plant breeders will gain a handful of seed that represents the new cultivar with good germination and high infection rate of live endophyte. This handful of seed provides the startup stock for creating bulk tonnages of seed for sales typically over four generations. This paper will focus on applying basic principles of seed production, storage, specification and sowing in a manner that retains physical and genetic purity, germination and living endophyte to ensure the resulting turf has the same agronomic features as the original plant material that the breeder provided.

This paper focuses on turf perennial ryegrass ***(****Lolium perenne)* and turf tall fescue *(Festuca arundinacea)*. Future papers will cover seed production processes for fine turfs such as Browntop *(Agrostis capillaris)*. It is intended that the reader will gain an appreciation for the added value in achieving a quality assured turf seed.

2 HIGH GRADE SEED PRODUCTION

The handful of seed provided by the plant breeder is increased under the management of the breeding company to create a small volume of Nucleus seed. The seed merchant then contracts selected growers for scaling up seed production to bulk tonnages under the guidance of the New Zealand Seed Certification scheme which typically follows through three more generations; Nucleus to Breeders, Breeders to Basic and Basic to First Generation (commercial grade).

2.1 SEED CERTIFICATION

One of the world's first authenticity and quality control systems was developed in New Zealand (NZ) beginning in 1929. Seed Certification provides a set of rules to track and maintain genetic purity, based on phenotypic expression, of cultivars during production (Rolston et al., 2006). Seed Certification is managed by the Seed Quality Management Authority (SQMA) made up of nominated industry representatives (AsureQuality 2010). Participation in the NZ Seed Certification Scheme is voluntary, and unlike most countries there is no seed law in NZ. However NZ growers enter almost all agricultural and turf seed crops into Seed Certification.

2.2 PADDOCK SELECTION

To avoid physical and genetic impurities in seed lines the crops have to be sown into clean soil. This is achieved through crop rotations and checks on paddock history records. Cereals, pulses, clovers vegetables and other crops alternative to grass seed allow the use of herbicides to clean up same species volunteer seeds and other grass weeds such as cocksfoot, bromes and poa which are unattractive in a turf. Soil sampling and testing for buried weed seeds is standard practice for early generation crops. Non selective herbicides such as Glyphosate are widely used pre-sowing and pre-emergence as a chemical fallow (Rolston et al., 2006).

Most grasses are out crossing species which means that they are open air pollinated. To maintain genetic purity seed production paddocks must be separated by distance isolation to minimize pollen contamination between different cultivars of the same species. Related species must also be isolated to avoid unwanted crossing; for example annual ryegrass pollen contamination in perennial ryegrass. Seed Certification sets isolation distance standards for commercial seed crops, while Nucleus productions have even wider distance standards.

Quality focused seed companies follow rigid guidelines for paddock selection, with Seed Certification standards used as a minimum back up for turf seed production.

2.3 FINDING TURF SEED GROWERS

Commercial turf seed growers are selected not only for paddocks that have low risk of contamination but also on their capability to deliver a quality product. Quality seed growers are proactive on weed and disease control and have good seed hygiene standards through harvest, transport and storage.

Top growers are also conscious of management techniques to protect the germination and endophyte. Turf seed crops require specialist management and higher inputs compared with many other arable crops and forages. There are also less useable bi-products from turf crops such as winter/spring grazing, silage and straw containing certain endophytes is not saleable for stock feed. Growers expect a price premium for turf seed production.

2.4 SOWING SEED CROPS

In New Zealand grass seed crops are either autumn, or the previous spring, sown and the plants have to experience low winter temperatures, followed by increasing day length to flower. Tall fescue is slower to establish and only autumn/early emerged tillers produce seed. Typically they are sown in spring or summer 15 to 18 months before harvest. (Pyke et al., 2010)
Seed production fields are drilled in evenly spaced rows to allow inspection for same or similar species volunteer contaminants. Higher grade paddocks that will be generating stock seed for further productions have wider row spacing allowing inter-row herbicide spraying. Contaminated paddocks are down-graded or removed from production depending on the severity of the contamination.

2.5 WEED AND DISEASE CONTROL IN SEED CROPS

Turf managers use high seeding rates, typically 10 times higher than sowing rates used in forages. Seed Certification standards were designed for the forage industry so seed companies producing high quality turf products have developed appropriate grower practices over and above the standards for certification. Suitable crop rotations are one mechanism for avoidance of weeds but extra control measures during the growing of turf seed crops is of utmost importance to avoid unattractive contaminants such as poa, phalaris and bromes along with a wide range of broadleaf weed seeds. Herbicide programs are an essential but expensive tool for seed growers. There is constantly evolving chemistry and applications of herbicides to provide better weed control.

Fungal diseases especially rusts (*Puccinia* spp.), are a common problem in grass seed crops and can cause large seed yield depression. Some cultivars of grass are very susceptible to rusts and fungicides are always used to control fungal diseases (Pyke et al., 2010). This is a significant issue for turf grasses that contain beneficial fungal endophyte as the applications of some fungicides are detrimental to endophyte infection of seeds and long term storability of live endophyte (Rolston et al., 2002). Continual research trials test new chemistry and mixes to find fungicide regimes suitable for applications to seed crops containing different endophyte strains.

Quality focused NZ seed companies employ their own Seed Researchers and Seed Production Agronomists to deliver evolving technology to the growers and recommend herbicide and fungicide mixes to be applied to turf seed crops at appropriate rates and timings that will achieve a quality product.

Crop spraying equipment used by New Zealand farmers and contractors has advanced in technology to the point where spray misses are no longer common.

2.6 SEED CROP MANAGEMENT

Along with weed and disease control other management techniques are important to achieve high yields, quality, uniformity of flowering and high endophyte levels. Nutrient management, irrigation, pest control and defoliation (closing date) all have to be given careful consideration.
Crops are also managed with Plant Growth Regulators (PGR's) with Trinexapac-ethyl the most commonly used on turf seed crops. PGR trails have demonstrated yield increases of up to 50% in ryegrass (nine trials) and up to 67% in tall fescue (six trials) (Rolston et al., 2004). PGR's are applied during the early stages of head emergence to keep the crop from lodging, increase uniformity of flowering and increase the number of mature seeds developed on individual seed heads.
Researchers and Agronomists are again responsible for delivering proven management techniques to turf seed growers.

2.7 HARVESTING / DRYING

As seed develops and matures it undergoes changes to survive in a dehydrated state. Endophytes also have to change to survive in this low moisture environment. Seeds are not all at the same physiological maturity at harvest because flowering and seed set is spread over approximately 14 days, the result of the hierarchy of tiller age, and a hierarchy of flowering within a seed head. Grass seed is commonly cut at about 40% Seed Moisture Content (SMC) and allowed to dry in a windrow for 7 to 10 days, then threshed with a combine harvester at 12-14% SMC. If the crop is cut early (>42% SMC) then fewer seeds will have endophyte that has entered a physiological state to survive well in storage (Pyke et al., 2010). If cutting is delayed seed losses from shattering can become an issue.

The weather during harvest, especially rain events that delay harvest, can have a detrimental effect on seed germination and endophyte viability. In years where seed is threshed at higher than desirable seed moisture for endophyte viability (> 11%) the seed must be dried with low humidity air (achieved by heating the air). The effect of drying speed, air temperature and potential interaction with seed moisture on endophyte viability has not been documented, but as poor drying practices can influence seed viability it is probable they will also impact on endophyte viability (Pyke et al., 2010).

Machinery hygiene is of high importance during harvest time, with equipment and transport containers needing to be free from potential contaminants. Growers need to be particularly aware of contractor's hygiene standards when outsourcing these services.

3 SEED CLEANING

Seed is cleaned in specialized processing plants to remove any remaining weed seeds, soil, straw and leaf contaminates. New Zealand has many independent seed cleaning facilities, particularly in Canterbury. There is a lot of pressure for quick turn-around from harvest to re-sowing, particularly with export seeds and those containing endophytes. Quality assured seed cleaning facilities are MAF registered and audited to ensure hygiene standards are adhered to and avoid contamination between seed lots. Cleaned seed lines are sampled by official Seed Sampling Officers trained to obtain accurate sub-samples representing a seed lot. Seed samples are then sent to accredited seed testing laboratories.

4 SEED TESTING

Independent seed testing laboratories are accredited by ISTA (International Seed Testing Association) and provide international Seed Analysis Certificates (Rolston et al., 2006). Seed testing is linked to the Seed Certification Scheme to ensure seed lines meet standard physical requirements. Seeds are tested for physical purity, germination and endophyte. Endophyte can be tested for the percentage of infected seeds. A seed squash or seed borne endophyte test only indicates presence and does not indicate the percentage of live endophyte in the seed. Live viable endophyte is currently measured as a grow out endophyte test and takes several weeks to be completed. Endophyte purity can also be tested to check for contaminant endophytes that may have come into the seed line via same species volunteer grass seeds.

Seed testing methods used in Certification Schemes measures seed germination and endophyte under laboratory conditions at a point in time. It does not guarantee seed germination or endophyte viability at a future date because seed germination and endophyte levels decline in time and at a rate influenced by the storage environment. Thus the date of the last test is critical.

Turf managers purchasing seeds should be able to obtain a Seed Analysis Certificate to match each particular seed lot and each component of a blended seed mix. This will provide purity information in terms of weed seeds, germination percentage to assist with sowing rate adjustments and the viable live endophyte level. The certificate also provides verification that the cultivar and species is true and correct.

5 SEED STORAGE

Seed viability is reduced by higher temperatures and higher seed moisture content (SMC), which is in equilibrium with relative humidity (RH%) (Copeland and McDonald 1995). As a rule of thumb the life of seed is doubled for every 5^{o}C decline in storage temperature or for every 1% decline in SMC (Copeland and McDonald 1995). These two effects are interdependent; thus a seed with low moisture content will survive higher temperature better than seed with high moisture. The two parameters (temperature and seed moisture) have an additive effect: thus a 5^{o}C cooling and a drop of 10% RH, resulting in a 1% decline in SMC, increases seed viability by four times. Seed endophyte viability is also driven by both temperature and SMC (Rolston et al., 1986); but the thresholds levels are much less and a decline in viability occurs after shorter exposure periods.

Typically, grass seed viability in an ambient temperature store averaging 15^{o}C and 70% RH will be maintained for 2 to 4 years. In contrast, endophyte viability in the same seed is maintained for only 0.5 to 1.5 years. The management and delivery of a high viability endophyte seed (>70% viability) is difficult and many traditional turf seed companies do the not have the experience and expertise to deliver a quality endophyte product. Companies that are serious about delivering quality endophyte are storing seed in controlled environments (Pyke et al., 2010).

To reduce the potential of loss of endophyte in the retail chain most companies are adopting ship-to-order policies so that the seed is moved from controlled environment storage to the end user when drilling is about to commence.

6 SOWING QUALITY TURF SEEDS

Turf managers need to be well prepared prior to sowing to ensure successful establishment and ongoing persistence of the new turf. The first thing to consider is that the location, rainfall/irrigation, pest pressures, soil type, pH and base fertility, adequately match the turf species and cultivar being chosen.

The second important step is to place an order for the seed. For modern high quality turf cultivars with endophyte technologies there can often be a time lag between request and sowing date, thus seed supplied for sowing is the result of a decision made at least 15 to 20 months earlier. The purchased seeds should be officially certified and accompanied by a current Seed Analysis Certificate as identity verification, and proof of purity, germination and viable endophyte level. Branded blends sold by a reputable merchant are also able to be traced back to each individual component to track Seed Analysis Certificates. Uncertified seed has a risk of poor genetic purity.

The next step is to prepare for best possible establishment. It is difficult to draw parallels between seed production crops and turf field sowings with the latter subject to restrictions on cultivation and timing. In a perfect world seeds should be drilled just below the surface into a moist, firm, cultivated seedbed with soil temperatures greater than 10 C^{o}. The seed bed should have had existing plants removed through herbicide applications and via mechanical cultivation. Nutrients should be immediately available for seedling establishment, by cultivating or drilling fertilizer into the soil with the sown seed. Pre and post emergence herbicides should also be used such as ethofumesate which is soil active to give several weeks of weed control. Stale seedbed techniques are also worth considering for cultivated grounds. The prepared seed bed can be left for a few weeks to allow germination of weeds with no further cultivation, then drill the seed and follow with pre-emergence glyphosate. Insecticide granules or coated seeds should also be sown for pest protection during seedling establishment when endophytes are not yet active. Some of the same principles could be applied to turf fields that are surface broadcast or over sown with the addition of daily watering during establishment. Direct drilling is the preferred option in many situations to minimize field disturbance, retain soil moisture and reduce germination of weed seeds.

Where possible the time of sowing should be chosen to avoid extremes of temperature. In mid-summer high temperatures and low moisture will quickly decimate young seedlings that have yet to establish a decent root system. Mid winter also poses risks such as frosts which can damage young

plants and in severe cases heave seedlings up out of the soil. Low ground temperatures hinder seedling emergence and plant growth. Many modern NZ bred turf ryegrasses have been through cycles of selection for low temperature germination. Most herbicides are ineffective when plants are not growing and soil active chemicals need reasonable soil moisture for activation. In New Zealand the best conditions for establishment occur during autumn and spring. There are differences in active weed growth between autumn and spring that need to be managed accordingly. Perennial grass plants which require vernalisation for reproductive activity will form fewer reproductive tillers, in the first season, when Spring sown.

Once the seed is purchased the turf manager should organize the delivery date to be as close as possible to the time of sowing to avoid reduction in quality. It is recommended that turf managers using products that make endophyte claims, obtain a Seed Analysis Certificate at the time of purchase with an endophyte viability test less than 6 months old for a novel endophyte and less than 12 months old for a wild-type endophyte. Any seed not sown should be stored in controlled conditions of low temperature and humidity to ensure germination and endophyte survival. Stored seed should be re-tested prior to sowing.

7 NEW ZEALAND SEED INDUSTRY

The New Zealand seed industry has developed a world class reputation in the ability to produce high quality seeds. NZ has also pioneered many plant based technologies such as fungal endophyte grass associations and learnt how to successfully deliver these technologies to end users. It is an industry that provides work to New Zealanders; seed growers, ag-contractors, chemical and nutrient distributers, irrigation and farm machinery suppliers, seed cleaners, seed company personal, researchers, agronomists, certification and testing agencies, seed storage facilities, transporters and more. Support of the NZ Seed Industry is key to retaining this valuable infrastructure and quality reputation.

8 CONCLUSIONS

Quality turf seed is not just a sack of goods that sits in the corner of a shed waiting to be sown. The humble seed is the delivery vehicle for plant technologies developed over many years of intensive breeding and quality assured production. Inclusion of fungal endophytes reinforces the fact that seeds are a living entity that need special handling to retain quality. Quality focused seed companies utilise rigid quality assurance protocols and testing alongside the NZ Seed certification Scheme to guarantee valuable high quality turf products. Turf managers can use Seed Analysis Certificates to verify the cultivar and the quality of the seeds and endophyte. Sowing decisions should be well planned to maximise value from modern turf products and to avoid long term storage from the time of delivery through till sowing. NZ certified seeds have a higher quality guarantee than inferior uncertified seeds.

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