# Breeding Winter Wheat for Increased Suppressive Ability against Italian Ryegrass

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## Introduction

Infestations of Italian ryegrass (*Lolium perenne* L. ssp. *multiflorum*) are problematic in both conventional and organic wheat production systems, and with the efficacy of herbicidal modes of action at risk and market opportunities for organic grain expanding, alternative or supplementary methods for control are worth exploring. Wheat cultivars with superior competitive ability against Italian ryegrass could play a role in maintaining acceptable yields and suppressing weed populations.

Suppressive ability is measured by cutting a quadrat from a weedy plot, separating the weed stems from the crop, and calculating the ratio of ryegrass to wheat biomass relative to the weed free plot (Coleman et al. 2001). This method is effective in studies with small numbers of plots, but impractical in large breeding programs.

Morphological traits such as height at the end of the growing season, tillering capacity, early biomass accumulation, leaf habit, and time to maturity (Lemerle et al., 1996; Lemerle et al., 2001; Mason et al., 2007) contribute to weed suppressive ability in spring wheat. It is unclear whether the same traits confer a competitive advantage to wheat in the long period of slow growth typical of southeastern winters.

The objectives of this study were to:

- Identify new screening methods for ryegrass suppressive ability of winter wheat cultivars that correlate well with ryegrass to wheat biomass ratios.
- Determine which morphological traits confer superior ryegrass suppressive ability to winter wheat cultivars in North Carolina.


**Figure 1.** Methods of rating suppressive ability **A)** spectrophotometer (NDVI) **B)** ryegrass seed heads $m^{-2}$ **C)** photographs and visual ratings **D)** wheat to ryegrass biomass ratios

## Materials and Methods

### Testing Potential Screening Methods

- Three locally adapted wheat lines overseeded with four rates of Italian ryegrass in a factorial treatment structure.
- Planted as a randomized complete block design at Caswell and Piedmont research stations, NC during the 2011 and 2012 seasons.
- Collected data using each method throughout the growing season (Figure 1).
- Forage harvester used to cut a 1.68 $m^2$ swath of wheat and Italian ryegrass stems in each plot. Ryegrass and wheat stems separated by hand and dried for one week at 40°C.
- LS means for each method from the twelve treatments were tested for correlation with ryegrass to wheat biomass ratios.

### Identifying Important Morphological Traits

- Sixty lines from the 2012 NC Official Variety Test (OVT) screened for suppressive ability at Caswell and Piedmont research stations.
- Morphological traits measured included visual ratings of early vigor (Zadoks 25 and 29) and growth habit (Zadoks 29), height notes (Zadoks 29, 31, 55, and 69), diffuse non-interception (DIFN; Zadoks 31 and 55), and heading date.
- Multiple regression employed to find the combination of traits which best predicted the ryegrass seed head density (Zadoks 69).
- Optimal model selection conducted using information criteria methods.

## Results

- Spectral signatures derived from overhead photographs and NDVI scores were not significantly correlated with ryegrass to wheat biomass ratios.
- Correlations between visual ratings and ryegrass to wheat biomass ratios were highly significant ($P < 0.01$), especially during heading ($r = 0.87$; Zadoks 55-60).
- The highest and most consistent correlations were found between ryegrass seed head density and ryegrass to wheat biomass ratios ($P < 0.01$; $r = 0.94$).
- Suppressive ability differed significantly among the OVT wheat lines. Average ryegrass seed heads $m^{-2}$ ranged from 42 to 196 at Piedmont and 81 to 180 at Caswell. Varietal rankings were consistent across environments.
- End of season height was not associated with suppressive ability.
- Area under height progress curve (AUHPC; calculated according to Shaner and Finney 1977) was the most important contributor to suppressive ability in both locations

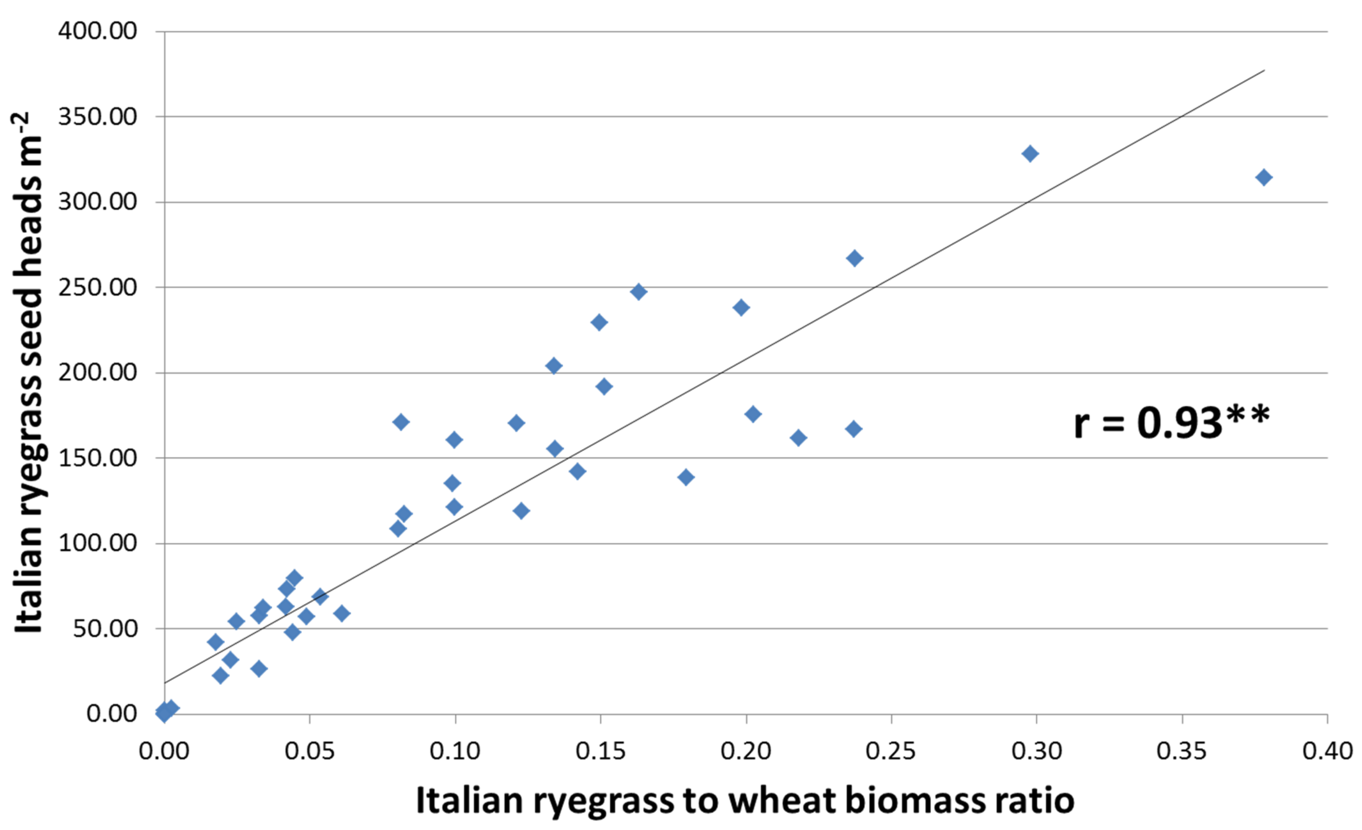


**Figure 2.** Relationship between ryegrass to wheat biomass ratio (Zadoks 80) and ryegrass seed heads density (Zadoks 69)

| Genotype | Ryegrass heads $m^{-2}$ | Early Vigor | Heading Date | Final Height | AUHPC | Grain Yield |
|---|---|---|---|---|---|---|
| **Most Suppressive Lines** | | | | | | |
| **AGS 2060** | 64 | 3.3 | 91 | 103 | 6257 | 66.7 |
| **AGS 2035** | 68 | 2.7 | 90 | 99 | 5892 | 75.7 |
| **AGS 2026** | 70 | 3.7 | 88 | 97 | 5689 | 75.2 |
| **DG Baldwin** | 74 | 4.0 | 98 | 105 | 5691 | 74 |
| **FVA 258** | 75 | 4.7 | 92 | 104 | 5226 | 80.4 |
| **Least Suppressive Lines** | | | | | | |
| **Progeny 870** | 141 | 6.3 | 101 | 89 | 4028 | 66.7 |
| **SS 8700** | 144 | 5.3 | 100 | 101 | 3936 | 64.0 |
| **AGS 2056** | 144 | 6.0 | 100 | 89 | 4140 | 67.2 |
| **P25R32** | 149 | 6.3 | 105 | 99 | 3648 | 60.6 |
| **USG 3438** | 188 | 8.3 | 100 | 90 | 4107 | 68.8 |

**Table 1:** LS means of important traits in the five most and least suppressive varieties averaged across locations

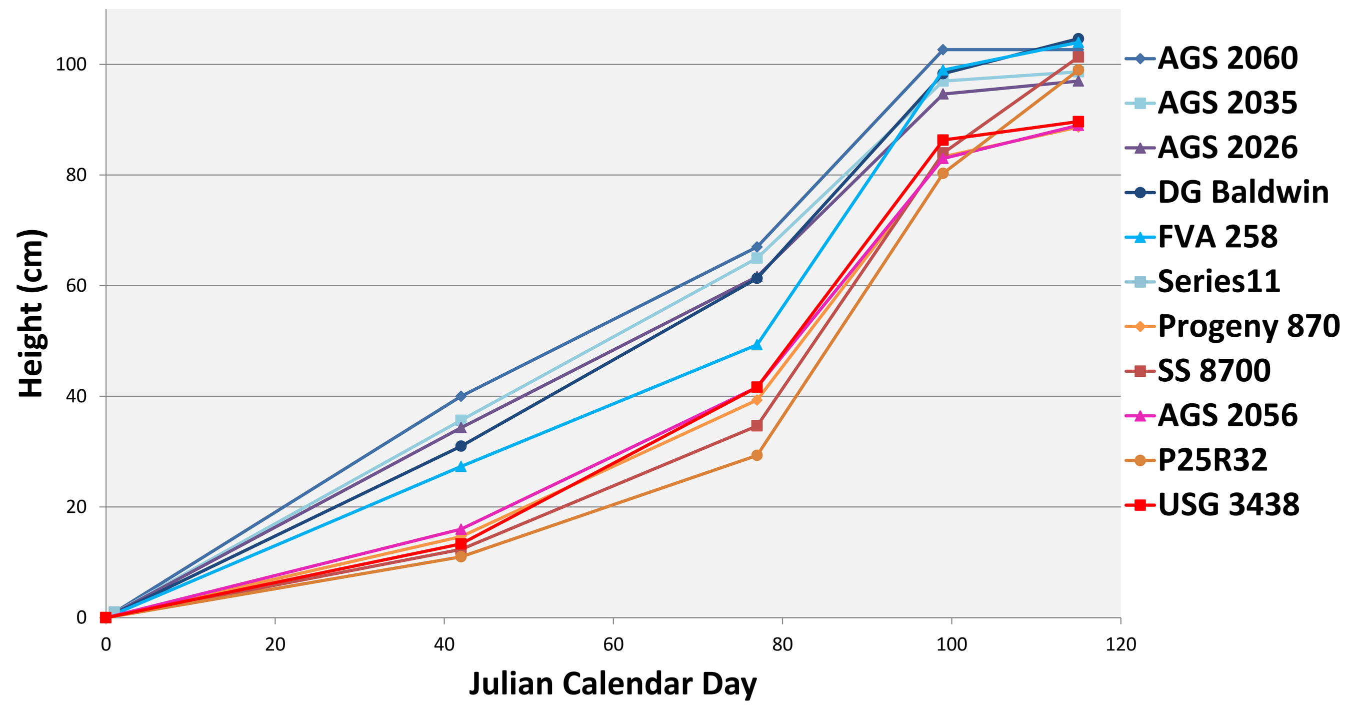


**Figure 3.** Height of the five most (in shades of blue) and least (in shades of red) suppressive varieties at Zadoks 29, 31, 55, and 69

| Model Variable | Partial $R^2$ | Model $R^2$ | Variable *P* value |
|---|---|---|---|
| **Piedmont 2012 ryegrass seed heads $m^{-2}$** | | | |
| **AUHPC** | 0.45 | 0.45 | <0.0001 |
| **Early vigor** | 0.04 | 0.49 | 0.0004 |
| Y= 238.50 - 0.03 (AUHPC) + 3.86 (early vigor) | | | |
| Full Model SBC = 1196.7 (lowest value), AIC = 1365.2 (second lowest ) | | | |
| **Caswell 2012 ryegrass seed heads $m^{-2}$** | | | |
| **AUHPC** | 0.16 | 0.16 | <0.0001 |
| **Heading date** | 0.02 | 0.18 | 0.0606 |
| Y= 94.97 - 0.01 (AUHPC) + 0.64 (heading date) | | | |
| Full Model SBC = 1196.7 (lowest value), AIC = 1365.2 (lowest value) | | | |

**Table 2.** Multiple regression models for influence of morphological traits on end of season ryegrass seed head density. Model variables include area under height progress curve (AUHPC), early vigor (rated at Zadoks 29 on a 1 – 10 scale with lower scores being the most vigorous), and heading date. Model criteria include Schwarz's Bayesian Criterion (SBC) and Akaike's Information Criterion (AIC).

## Conclusions

- Visual ratings of weed biomass and ryegrass seed head $m^{-2}$ counts are appropriate screening methods for ryegrass suppressive ability in large breeding programs.
- Simple, inexpensive, and strongly correlated with ryegrass to wheat biomass ratios.
- There is a large amount of variation in ryegrass suppressive ability within adapted southeastern winter wheat germplasm.
- The most suppressive lines were also among the highest yielding under conventional conditions in the 2012 OVT.
- The most suppressive winter wheat lines are generally vigorous during tillering, early maturing, and tall throughout the growing season.
- The traits which contribute to ryegrass suppressive ability in spring wheat cultivars will not necessarily confer a competitive advantage to winter wheat lines in NC.

## References

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