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The impact of seed size and chemical composition on seedling vigor, yield, and fiber quality of cotton in five production environments

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ABSTRACT

Seed mass and oil content of the quiescent cotton seed are positively associated with seedling vigor. In contrast, seed size has been negatively associated with lint yield due to selection for cultivars with greater lint percent. The current study addressed the hypothesis that planting seed mass and total oil + protein calorie content of the quiescent cotton seed would be strongly predictive of seedling vigor across most field conditions and that the impact of seed traits on yield would be dependent upon yield environment. When considered in each yield environment, seedling vigor was positively associated with seed size and the total oil + protein calorie content per seed in four out five environments tested. Regression analysis of cultivar mean oil + protein kcal content per seed versus seedling vigor across all environments indicated a strong, positive relationship between the two parameters ($r^2 = 0.65$). Although lint percent was positively correlated with lint yield in every environment, planting seed mass and calorie content were not correlated with lint yield in four of the five environments tested or when cultivar means for lint yield and seed characteristics were averaged across all environments. Thus, it is concluded that individual planting seed mass and total energy content for oil + protein are strong predictors of early seedling vigor. Furthermore, selecting commercially available cultivars with characteristics indicative of seedling vigor does not appear to limit lint yield in most environments tested.

1. Introduction

Cotton production faces many challenges that have the potential to increase risk and limit economic productivity. For example, seed technology fees have increased substantially, which necessitates good stand establishment and high yields if cotton production is to be profitable. Vigorous seedling growth soon after planting promotes stand establishment and minimizes grower risk in a number of different ways. For example, early work by Wanjura et al. (1969) indicated that time to emergence (the authors' particular measure of seedling vigor) was closely associated with final lint yield when planting depth was altered to generate differences in time to emergence. Vigorous seedling growth decreases susceptibility to disease and early season insect herbivory (Elliott et al., 2008; Liu et al., 2015; Snider and Oosterhuis, 2015) and rapid canopy closure improves interspecific competition with weedy plant species (Reddy and Boykin, 2010). Rapid early season canopy development would maximize light interception at a time when daily incoming solar radiation is at its peak (Snider and Oosterhuis, 2015). Furthermore, cotton cultivars that produce large plants with extensive root systems prior to flowering produce higher yields under dryland conditions than those with slower growth prior to flowering (Cook and El-Zik, 1992). Although vigorous seedling growth does not always translate to higher yields for field-grown cotton (Liu et al., 2015), the advantages noted previously minimize the risk of stand loss. Stand establishment issues can be remedied by replanting, but the decision to replant is inherently costly and limits the profitability of cotton production (Snider and Oosterhuis, 2015).

Given the importance of seedling vigor, a number of researchers over multiple decades have attempted to identify seed characteristics that could be used to predict vigor. In cotton, seed size, the degree of seed filling, seed density, and seed nutrient content and composition (Ferguson and Turner, 1971; Bartee and

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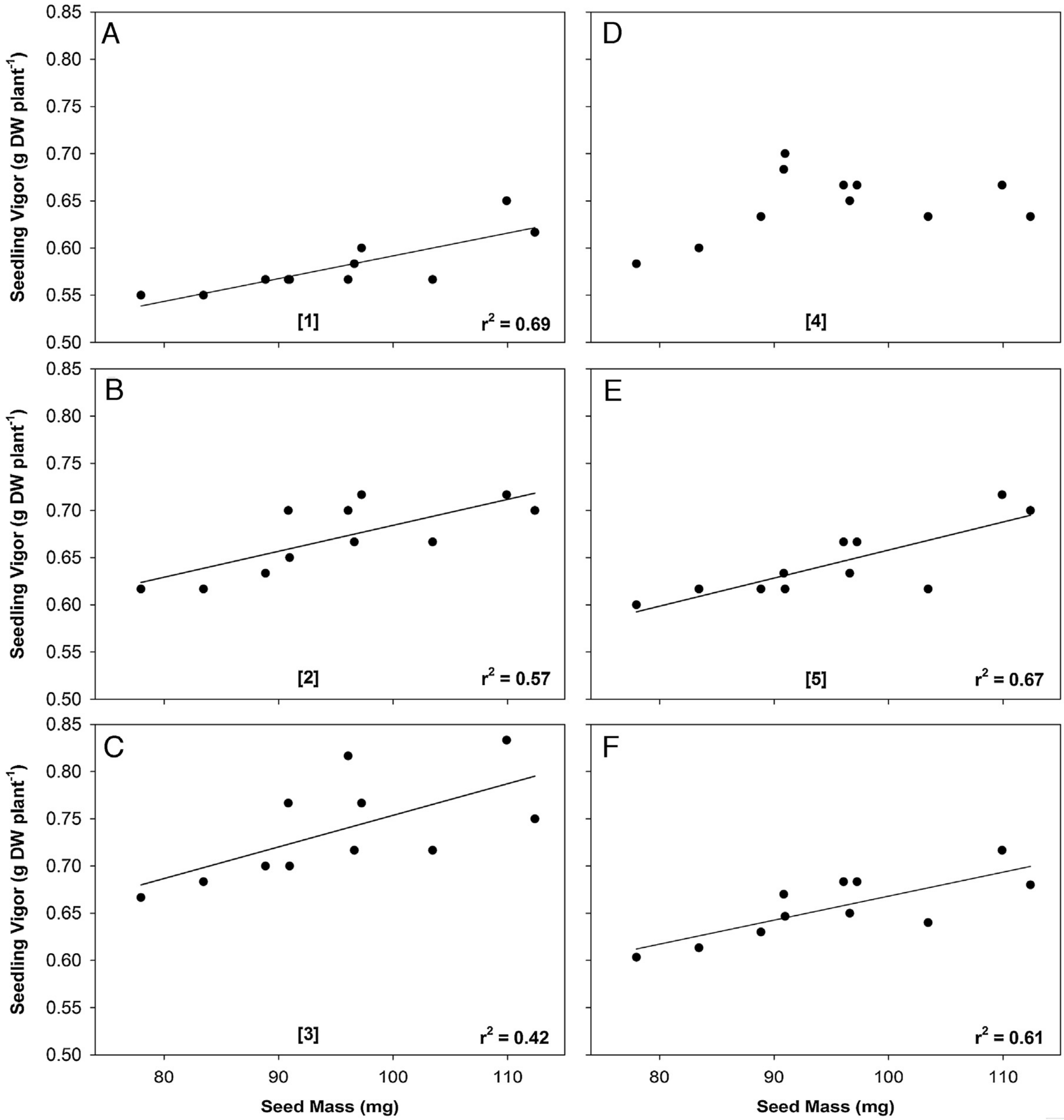

Fig. 1. The relationship between planting seed individual seed mass and seedling vigor (seedling dry weight at the 2–3 leaf stage) for 11 different seed lots in each of five different production environments (A–E; Bracketed numbers represent each environment noted in Table 1 and Table 2) or averaged for a given seed lot across all five environments during the 2012 growing season (F).

Krieg, 1974; Krieg and Bartee, 1975; Leffler and Williams, 1983; Snider et al., 2014) have all been proposed indicators of seedling vigor. Specifically, recent work has indicated that cultivar differences in seed mass and total oil content per seed are positively associated with early seedling vigor (seedling fresh weight at the 2–3 leaf stage) (Snider et al., 2014) when considered as cultivar means (11 cultivars evaluated) across five different production environments in Georgia. The relationship between seed characteristics and early seedling vigor should be considered in the context of seed germination and seedling growth preceding the transition to photosynthetic autotrophy. During the first day following seed imbibition, metabolic activity increases and is initially fueled by seed oil and protein reserves (Turley and Chapman, 2010). Following radical protrusion, the lipid and protein reserves of the cotyledons are the dominant energy source used to drive growth before the cotyledons become photosynthetically competent (Snider and Oosterhuis, 2015; Turley and Chapman, 2010). In addition to the work noted by Snider et al. (2014), previous authors have also suggested that oil and protein content per seed could be suitable indicators of seedling vigor (Abdelmagid and Osman, 1975 Bartee and Krieg, 1974). Importantly, the quantity and composition of cottonseed macronutrients has been shown to vary among modern cultivars (Dowd et al., 2010; Pettigrew and Dowd, 2012; Snider et al., 2014), and variation in seedling vigor can be associated with varietal differences in seed characteristics or the seed production and storage environment (Abdelmagid and Osman, 1975; Kerby et al., 1989; Peacock and Hawkins, 1970). Thus, for a given seed lot, the total oil and protein content per seed may represent a strong indicator of vigor, regardless of whether variation in seed and seedling characteristics is genotype or environment-based. Recent, non-destructive methods that allow for simultaneous quantitation of seed oil and protein concentration of whole cottonseed (Horn et al., 2011) may be valuable tools for predicting seedling vigor in a seed lot-dependent manner.

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