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Deficit irrigation for optimum cotton yield and seed quality

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Introduction

Cotton (*Gossipium hirsutum* L.) is one of the most important fiber-producing plants throughout the world. Stand establishment of cotton seedling is one of the most critical stages in cotton production (Sawan et al., 1999). Stand failures result from many factors including poor seedbed preparation, low temperatures, excess of insufficient moisture, soil micro-organisms and other pests, chemical injury, and low-quality seed (Mc-Carter and Roncadori, 1971). Low-quality seed may be a major contributing factor in many stand failures, since seeds are very susceptible to adverse conditions and stresses in the seedbed environment. Drought stress (Heatherly, 1993; Smiciklas et al., 1992), high temperature (Spears et al., 1997; Zankis et al., 1994), alternate wetting and drying (Woodstock et al., 1985; Dornbos et al., 1995) and high humidity and rainfall (Castillo et al., 1994) have all been shown to have adverse effects on seed quality. Thus, the quality of planting seed is affected by conditions the seeds sustain during development.

Irrigation scheduling based on developmental stage or deficit irrigation is the technique of applying water on a timely and accurate basis to the crop, and is the key to conserving water and improving irrigation performance and sustainability of irrigated agriculture (Mpelasoka et al., 2001). Water availability and cultural practices may influence not only the interrelationships between seed yield and its components but also the seed quality characteristics. Vieira et al. (1991) in soybean reported that drought stress caused yield reductions, but found no effect on seed quality. While and Heatherly (1993) reported that drought stress during the seed filling period in soybean caused significant reductions in seed quality. The effects of irrigation regimes on yield and yield components of cotton are well known, but we have found no report on the effect of irrigation regimes on cottonseed quality. Thus, our objective was to evaluate the effects of irrigation regimes on cotton yield and seed quality and determine the level of deficit irrigation that optimizes cotton yield and seed quality in Golestan province of Iran.

Material and Methods

Field experiments were conducted at the Research Station of Cotton, Hashem-Abad, Gorgan, in northern Iran during the growing season 2006 and 2007. Cotton (*Gossypium hirsutum* cv Sepid) was sown on 24 April in 2006 and on 30 April in 2007 into rows (80 cm between rows and 10 cm within the row). Four different irrigation regimes (0, 40, 70 and 100%PE) were with three replicates of each treatment in a randomized complete block design. After the start of flowering, the cotton was irrigated with drip tape (Eurodrip). Water requirements for the crop were estimated on the basis of the evaporated water, calculated from a Class A pan evaporation (PE). Further irrigations were applied when the cumulative evaporation amount from class A pan reached approximately 40-50 mm. The plants were harvested by hand picking, and immediately after delinting, the seeds were thoroughly rinsed with deionised water and dried under shade. The seeds were stored in a refrigerator until used.

The seed quality was evaluated by standard germination and vigor tests in the laboratory following a randomized complete block design with four replicates of 50 seeds in all experiments.

Data from the field and Laboratory experiments were subjected to analysis of variance and means of treatments were compared using least significant difference (LSD) at 5% levels of probability.

Results and Discussion

Cotton yields showed quadratic responses to %PE, increasing, reaching a maximum at 80-93%PE, and then decreasing with increasing %PE (Fig.1). Doorenbos and Kassam (1979) indicated that the maximum cotton yield was usually obtained when the cotton plants were irrigated at 50–60% of available water holding capacity.

Seed weight increased with increasing %PE each year, up to a maximum at 63-100%PE (Fig.1). Shock et al. (2007) reported that seed weight of alfalfa increased with increasing water levels. They also reported that highest seed weight in alfalfa was obtained at 73% ETc replacement. By contrast, Iannucci et al. (2002) found that 1000-seed weight of alfalfa increased in the absence of irrigation. Brown et al. (1977) also reported that irrigation treatment had only a slight effect on seed weight. Bannayan et al. (2008) reported that the lowest seed yield of black cumin was obtained when irrigation was stopped at the blooming stage, but thousand seed weight was relatively stable across all irrigation treatments.

Germination and vigor of seeds generally increased with decreasing irrigation levels each year (Table 1). Shock et al. (2007) in alfalfa also reported that germination decreased with increasing water levels and maximum germination achieved with 21% ET_c replacement. In contrast, Heatherly (1993) reported that irrigation initiated during flowering and continued into the seed-fill period significantly increased standard germination of soybean seed. Vieira et al. (1992) also found that water stress increased seed conductivity in soybean cultivars. Ghassemi-Golezani et al. (1997) on maize and sorghum and Vieira et al. (1992) on soybean and Iannucci et al. (2002) on alfalfa reported that although water limitation whole growing season could reduce yield, it had no any significant effect on their seed germination.

The results indicated some clear guidelines for producing the seed cotton yield and cottonseed in the north of Iran. The results of this study show that although water limited could reduce cotton yield, but highest seed quality was observed with non-irrigation condition. The results also indicate that an irrigation treatment of 40%PE would be the optimum for cotton yield and seed quality production under drip irrigation.

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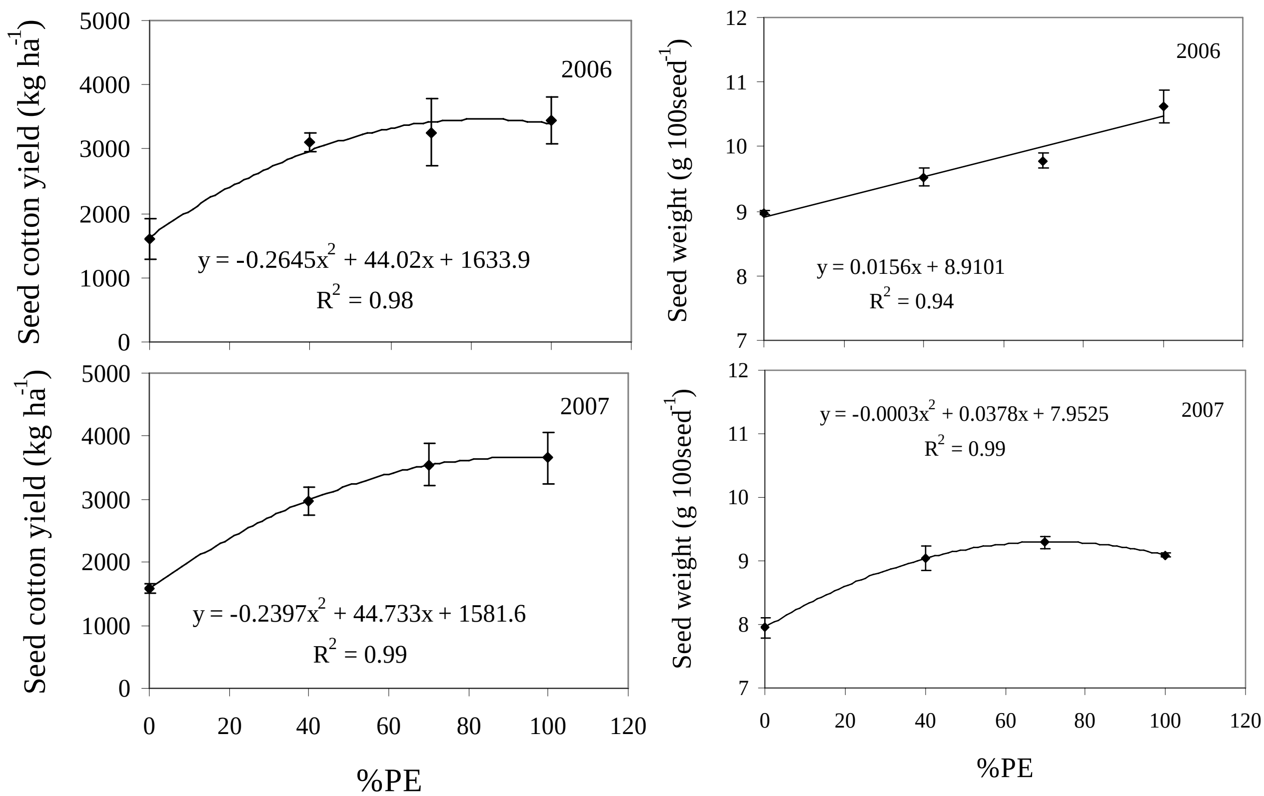

Fig. 1. Seed cotton yield and seed weight to irrigation treatment.

Table 4. Analysis of variance for seed quality tests and average values in 2006 and 2007 from different treatments.

Variation source	DF	Conductivity		Seedling growth rate				Standard germination				Cool-germination	
				Seedling length		Seedling dry weight		Percentage		Rate		Percentage	
		(μS cm^{-1} g^{-1})		(cm)		(mg d^{-1})				(h^{-1})			
		F Value	Pr > F	F Value	Pr > F	F Value	Pr > F	F Value	Pr > F	F Value	Pr > F	F Value	Pr > F
Year		630.14	<0.0001	15.39	0.0078	12.91	0.0115	0.60	0.4736	133.35	<0.0001	15.45	0.0077
Treatment		9.38	0.0008	18.80	<0.0001	5.40	0.0093	3.31	0.0572	11.06	0.0002	1.10	0.3807
Trt × year		15.33	<0.0001	5.21	0.0106	1.89	0.1716	1.08	0.3945	5.19	0.0093	3.89	0.0306
Irrigation regimes (%PE)		2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
100		30.0	36.3	15.3	11.9	21.4	17.8	75.0	75.0	0.0274	0.0353	74.0	38.8
70		24.5	39.6	17.9	12.5	24.9	18.0	86.7	80.0	0.0268	0.0363	68.0	57.8
40		26.8	29.9	18.2	16.9	25.0	24.7	82.0	90.0	0.0266	0.0361	76.0	46.5
0		26.2	38.5	19.9	21.6	25.9	24.1	87.0	97.5	0.0398	0.0384	69.5	60.0
$LSD_{(0.05)}$		2.22	3.04	2.33	3.15	NS	4.91	NS	11.12	0.00568	NS	NS	15.32