THE COST AND BENEFIT OF IRRIGATION AND CROP ROTATION FOR COTTON GROWN IN A VERTICILLIUM WILT FIELD IN THE SOUTHERN HIGH PLAINS OF TEXAS

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Abstract

The Southern High Plains of Texas has historically had problems with Verticillium wilt. Management of Verticillium wilt is difficult, so there has been little work to determine the cost/benefit of management of this disease in cotton. Research was conducted to compare economically a system of continuous cotton to rotated cotton (2-year cotton/1-year sorghum). Three different irrigation rates; Base (1.0B), Base -50% (0.5B), and Base + 50% (1.5B) were used and partially resistant and susceptible varieties. The average mean return above total specified expenses for 2007-2012 (2011 excluded) was calculated. For first three years (2007-2009), the targeted evapotranspiration (ET) of 1.0B was 80%, and the other two years (2010 and 2012) Base ET targeted 60%. From 2007 – 2009 the rotated system had better economic returns ($170.08/acre) than continuous cotton ($48.79/acre) and from 2010 and 2012, rotated cotton had $15/ac higher returns than continuous cotton. With ET=60%, both 1.0B ($242.40/ac) and 1.5B ($261.84/ac) had good economic returns and higher than 0.5B ($-15.69). With ET=80%, 1.0B ($70.89/ac) had higher returns than 0.5B ($-59.73/ac) and 1.5B ($19.37/ac). With ET=60, the partially resistant cultivar ($171.38/ac) returned $17/a more than the susceptible cultivar, and when ET=80, resistant cultivar ($36.28/ac) had $52/a higher returns than the susceptible variety (-$15.94). Overall highest economic returns were achieved from rotated cotton with 60% ET. Partially resistant cultivar had better economic returns when compared to susceptible cultivar. 1.5B irrigation had better economic returns with 1.0B=60% ET but 1.0B gave better returns than other irrigation rates with 1.0B= 80% ET.

Introduction

Verticillium dahliae is one of the most important diseases of crops (Menzies, 1967, Pegg, 1974), as it reduces about 1.5 million bales of annual cotton yield (Bell, 2001). From 2004 to 2010, this disease was arguably the most important biotic yield limiting factor on cotton in the Southern High Plains of Texas (T. Wheeler, personal observation). The disease infects the cotton plant which leads to chlorosis and necrosis in leaf and stem (Fig. 1, 2). It causes the plant to defoliate prematurely, stunting of plants and substantial yield loss (Berlanger, 2000).

Currently there are no fungicides recommended for controlling Verticillium wilt in cotton. However, some practices like the use of partially resistant and wilt tolerant cultivars, crop rotation with non host crops like sorghum, not over-irrigating, and a high seedling rate are recommended (Pullman and DeVay, 1981). The major objective of this research is to determine the cost/benefit of crop rotation, irrigation and cultivar selection for cotton grown in a *Verticillium dahliae* infested field.

Fig 1. Light brown vascular discoloration seen in cotton stem due to Verticillium wilt

Fig 2. Wilting of cotton leaf due to Verticillium wilt

Materials and Methods

The research was conducted at the Texas A&M AgriLife Research site in Halfway, Texas. The test site was initiated in 2001, with wedges B, C, and D (Fig. 3) in a 2 yr cotton and 1 yr grain (corn or sorghum) rotation; and wedges A, E, and F in continuous cotton. The first wilt appeared in 2007, and wilt was seen every year since 2007. The systems treatments were continuous cotton (wedge E, CCC, Fig. 3) and 2 yr cotton+1 yr sorghum (wedges B, C, D [ROT]). Within each wedge, there were 3-4 spans involved with the experiment. Within each span there were three irrigation rates, Base (1.0B), Base+50% (1.5B), and Base-50% (0.5B) that each covered about 20 rows and were randomized. There were six rows in each B-50% treatment that were dryland within the pivot. The plants were irrigated up initially and then no water was applied for those six rows (in each span) for the rest of the season.

During 2007-2009, the base irrigation rate was designed to meet about 80% of the evapotranspiration (ET) needs of the crop, when pumping capacity was sufficient. Then because of a reduced pumping capacity over time, this level was reduced to 60% ET for 2010-2013. Within each irrigation treatment, a partially resistant and susceptible variety to Verticillium wilt was planted. The varieties did change over time. Irrigation rate and fertilizer rate were different depending on the wedge and irrigation treatment designation. Most other inputs were kept constant. Yield, fertilizer, irrigation amounts and most inputs can be found in Helms Annual Report at http:/lubbock.tamu.edu/programs/disciplines/irrigation-water/helms-farm-research-reports/

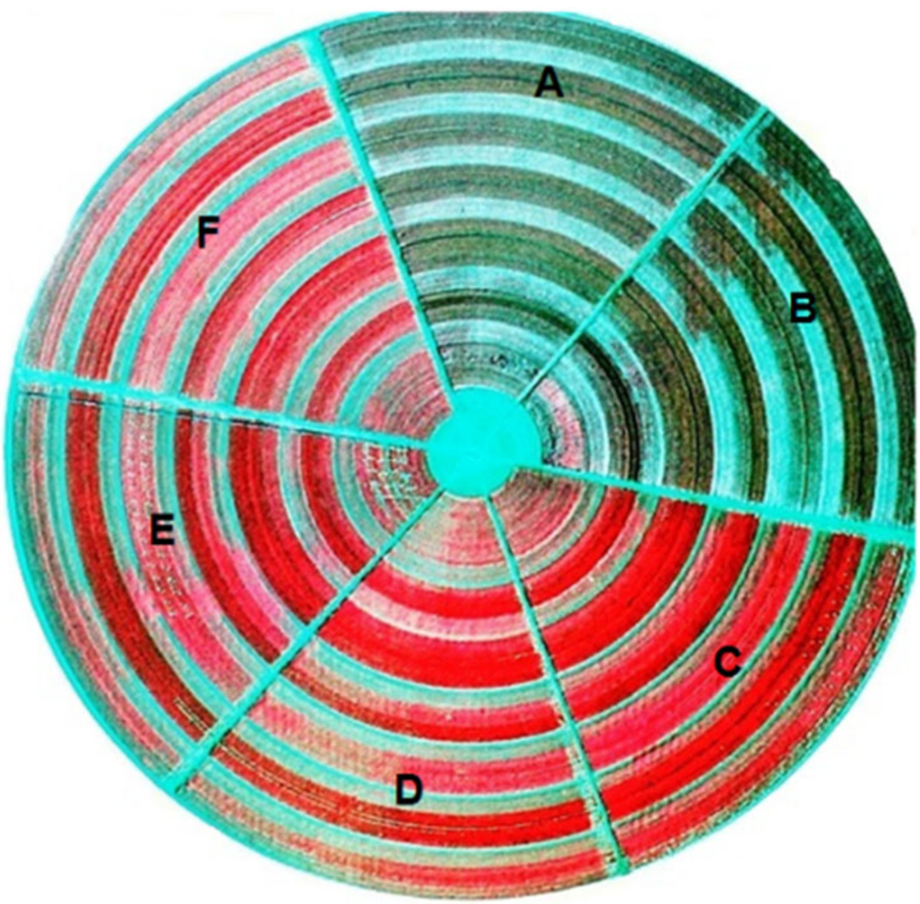

Fig 3. Helms research farm is divided into six wedges. Wedges B, C, and D were used for the crop rotation treatment and Wedge E was used for the continuous cotton treatment. The light colored wedges have sorghum planted in this particular year and darker wedges have cotton planted. Each 64 row span of the pivot has three irrigation rates (Base-50%, Base, and Base+50%), where the brighter red color indicates a higher irrigation rate and the more greenish color indicates the Base-50% irrigation rate.

Calculation of Economic Returns

Various costs that were associated with center pivot irrigated cotton and dryland cotton together with center pivot irrigated sorghum and dryland sorghum were used to calculate the returns above specified expenses for each combination and irrigation levels. The data provided in Helms Annual Report from 2007-2012 for South Plains region were used for the calculation. Various price rates for cotton were used. For 2007 $0.54/lbs, 2008 $0.60/lbs, 2009

$0.54/lbs, 2010 $0.62/lbs, 2011 $0.90/lbs, and 2012 $0.80/lbs were used. Similarly the sorghum ($/cwt) prices were; in 2007 $5.60, 2008 $6.43, 2009 $8.1, 2010 $6.70, 2011 $8.25, and 2012 $9.3. All these prices were converted to 2013 money value using "CPI inflation calculator' from Bureau of Labor Statistics.

For calculation of irrigation cost, the labor and fuel cost for center was calculated in $/acre inch irrigation. In 2007 $8.88/ac inch, 2008 $12.64, 2009 $12.64, 2010 $8.64, 2011 10.64, and 2012 $9.64/ ac inch irrigation was calculated. Total cotton income was calculated in $/acre.

TCI= (Lq*Lp + Sq*Sp)

Where;

Lq= Lint quantity (lbs)

Lp= Lint price ($)

Sq= Seed quantity (Tons)

Sp= Seed price ($)

Total direct expenses (TDEC) for cotton was calculated by adding all the expenses with seed treatments, fertilizers, herbicides, ginning, insurance, irrigation, implements & tractors, irrigation labor, diesel, repair and maintenance and miscellaneous. All these expenses was calculated in $/acre.

Returns above direct expenses of cotton were calculated by subtracting total direct expenses for cotton from the total income. Total fixed expenses of cotton (TFEC) like implement, tractor, irrigation, and pick up was also subtracted from total returns.

So the returns above total specified expenses of cotton were calculated by following formula:

RATSEC = [{(Lq*Lp + Sq*Sp) – TDEC} – TFEC]

Similarly for Sorghum,

Total sorghum income was calculated in $/acre. The price of sorghum was multiplied with the quantity to calculate the total income. Total direct expenses like seed, fertilizers, labor, irrigation, diesel, repair and maintenance, and other miscellaneous expenses were also calculated. Returns above direct expenses of sorghum were calculated by subtracting the total direct expense from total income of sorghum. Returns above total specified expenses of sorghum were calculated by

RATSES = [{(SorQ * SorP) – TDES} – TFES]

SorQ= Sorghum quantity (cwt)

SorP= Sorghum price ($)

TDES= Total direct expenses of sorghum

TFES= Total fixed expenses of sorghum

Finally, the overall Returns Above Total Specified Expenses were calculated by:

[{(Lq*Lp + Sq*Sp) – TDE} – TFE] + [{(SorQ * SorP) – TDES} – TFES]

Result and Discussion

Cropping system

From 2007 – 2009 (ET=80% for 1.0B), the rotated system had better economic returns ($170.08/acre) than continuous cotton ($48.79/acre) (Fig. 4). From 2010 and 2012 (ET=60 for 1.0B), both continuous cotton and rotated cotton had good economic returns, however with rotated cotton, the economic returns were about $15/ac more than continuous cotton (Fig. 4).

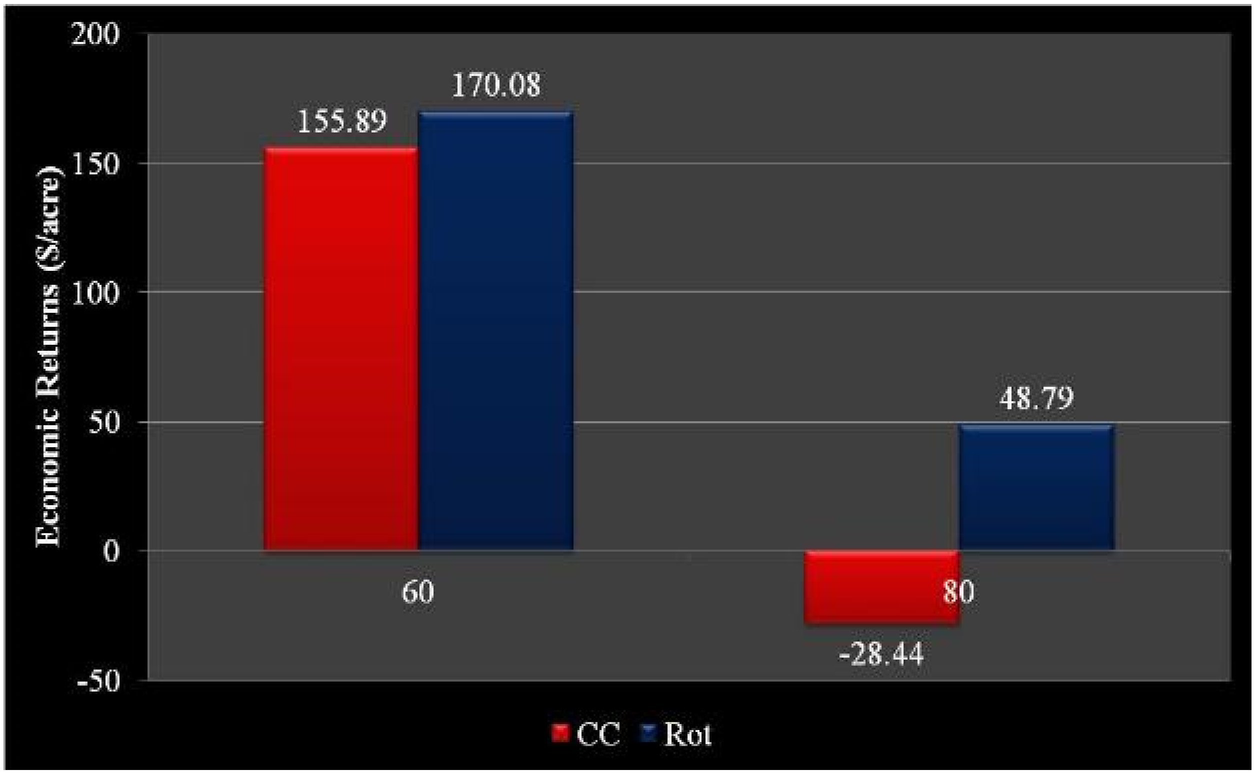

Fig 4. Comparison of economic returns ($/ac) between two cropping systems. CC represented continuous cotton and Rot represented a rotation with 2 years of cotton and 1 year of sorghum. The systems were compared in 2007 – 2009 (where the base irrigation rated targeted an evapotranspiration (ET) rate of 80%, and in 2010 and 2012 when the base irrigation rate targeted and ET of 60%.

Economic Returns vs Irrigation

When ET was 60% for the base irrigation rate, both 1.0B and 1.5B did well regarding the economic returns, with average returns of $242.40/ac and $261.84/ac, respectively (Fig. 5). The returns for 0.5B were poor ($15.29/acre). However, with ET=80% for the base irrigation rate, 1.0B had higher average returns ($70.89/ac) than 0.5B (-$59.73/ac) and 1.5B ($19.37/ac). In both cases of ET = 60 and 80, 0.5B had negative returns (Fig. 5). Since the years and varieties were different between ET=60 and ET=80, it is not known whether overall irrigation being higher in 2007-2009 versus 2010-2012 was the reason for the relatively poor returns during 2007-2009 (ET=80 for 1.0B), whether the different varieties in use over those years was the reason, or some other unknown factor. Verticillium wilt is worse under wetter and cooler conditions, so the higher pumping capacity in the earlier years of this study may have resulted in the poorer economic returns, especially for 1.0B and 1.5B.

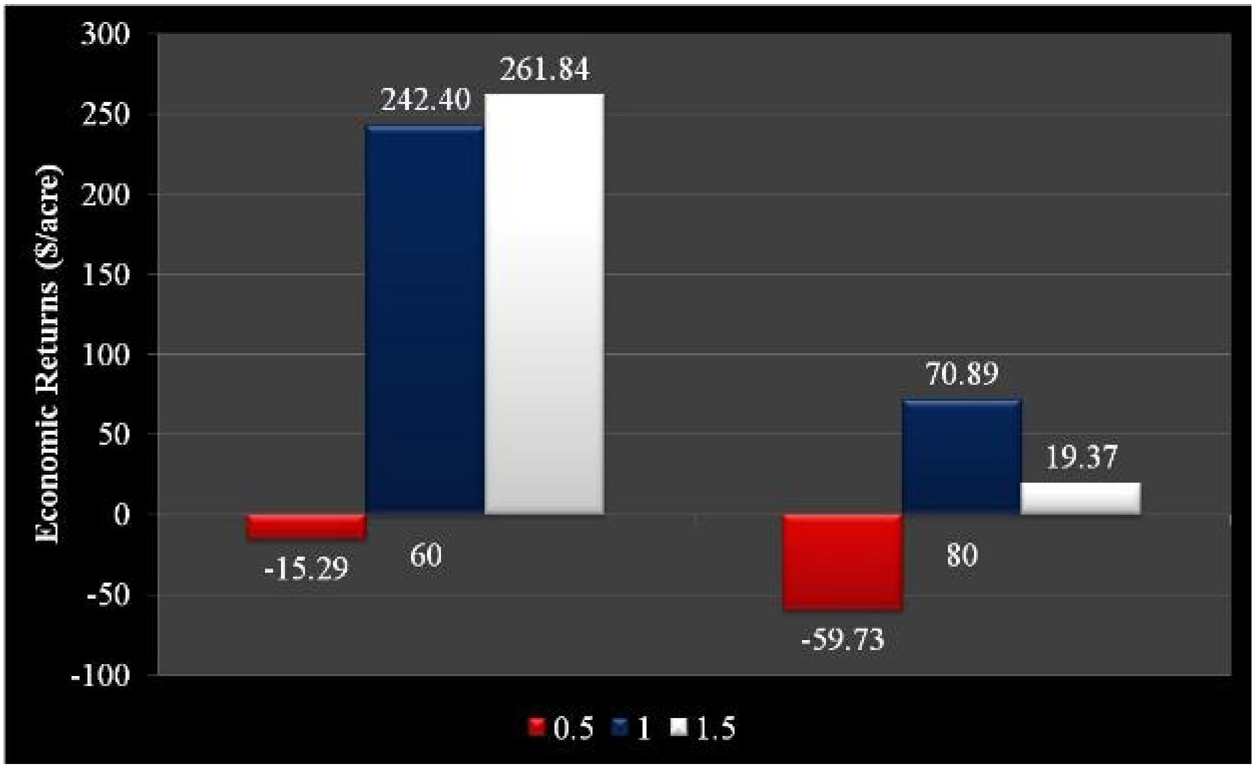

Fig 5. Economic returns vs different irrigation levels when the evapotranspiration (ET) of the base irrigation rate was 60% and 80%. The three irrigation levels were represented by 0.5 as base-50%, 1 as base, and 1.5 as base+50%.

Economic Returns vs Cultivar

When ET=60%, the partially resistant cultivar returned $17/a more than the susceptible cultivar (Fig. 6). However, under better disease conditions (ET=80% for 1.0B), the partially resistant cultivar returned $52/acre more than the susceptible cultivar (Fig. 6). The partially resistant cultivar is a better option in Verticillium wilt cotton fields, but the advantage improves as conditions for wilt become more conducive (i.e. wetter and cooler).

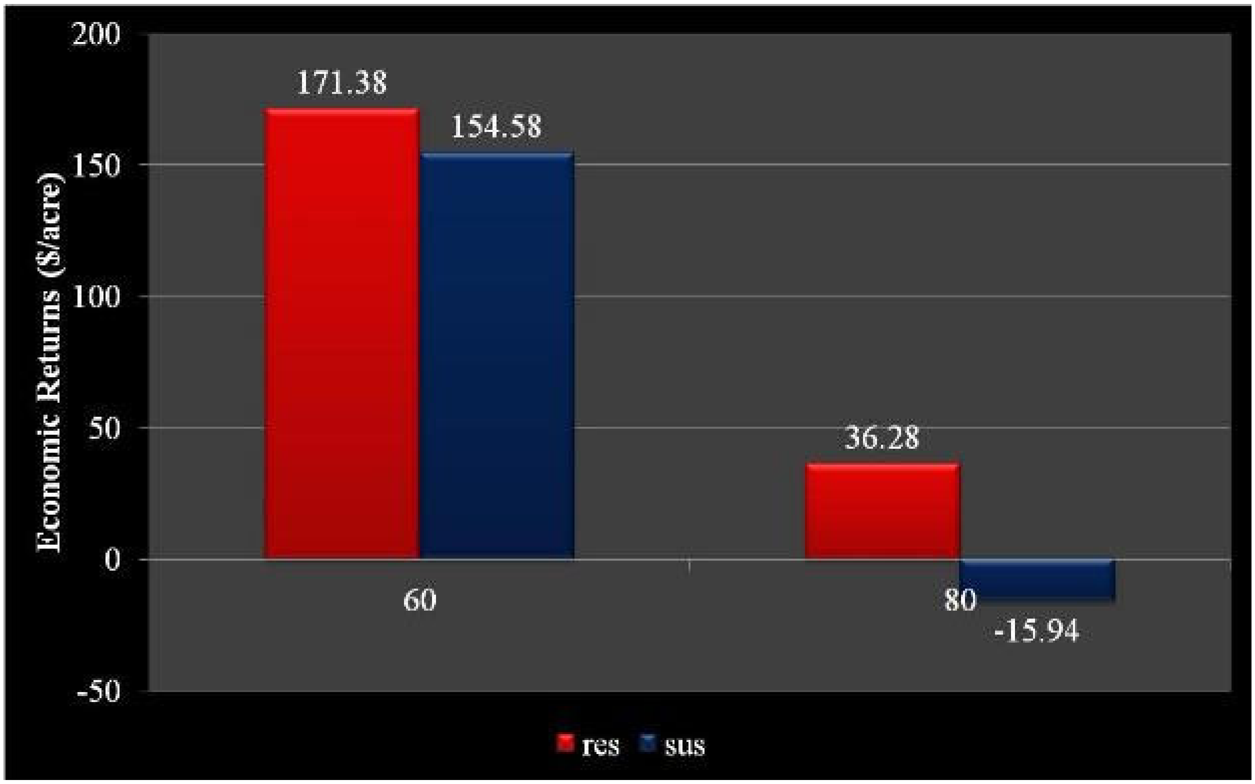

Fig 6. Economic returns vs partially resistant (res) and susceptible (sus) cultivars to Verticillium wilt when the evapotranspiration (ET) of the base irrigation rate was 60% & 80%. Variety effects were averaged over two cropping systems and three irrigation rates.

Economic returns of irrigation vs cultivar interaction

There was an irrigation rate x variety interaction with respect to economic returns. The partially resistant variety did better than the susceptible variety with base and base+50% irrigation rates; however the susceptible variety had higher returns than the partially resistant cultivar at 0.5B irrigation rate (Fig. 7). The 1.0B irrigation rate had a higher return than the 0.5B or 1.5B irrigation rates when ET=60% for the susceptible variety, and with ET=80%for both varieties (Fig. 7). Therefore, higher irrigation rates do-not always give the highest economic returns, especially when Verticillium wilt is increased at higher irrigation rates. Though, too little water always gave poor returns.

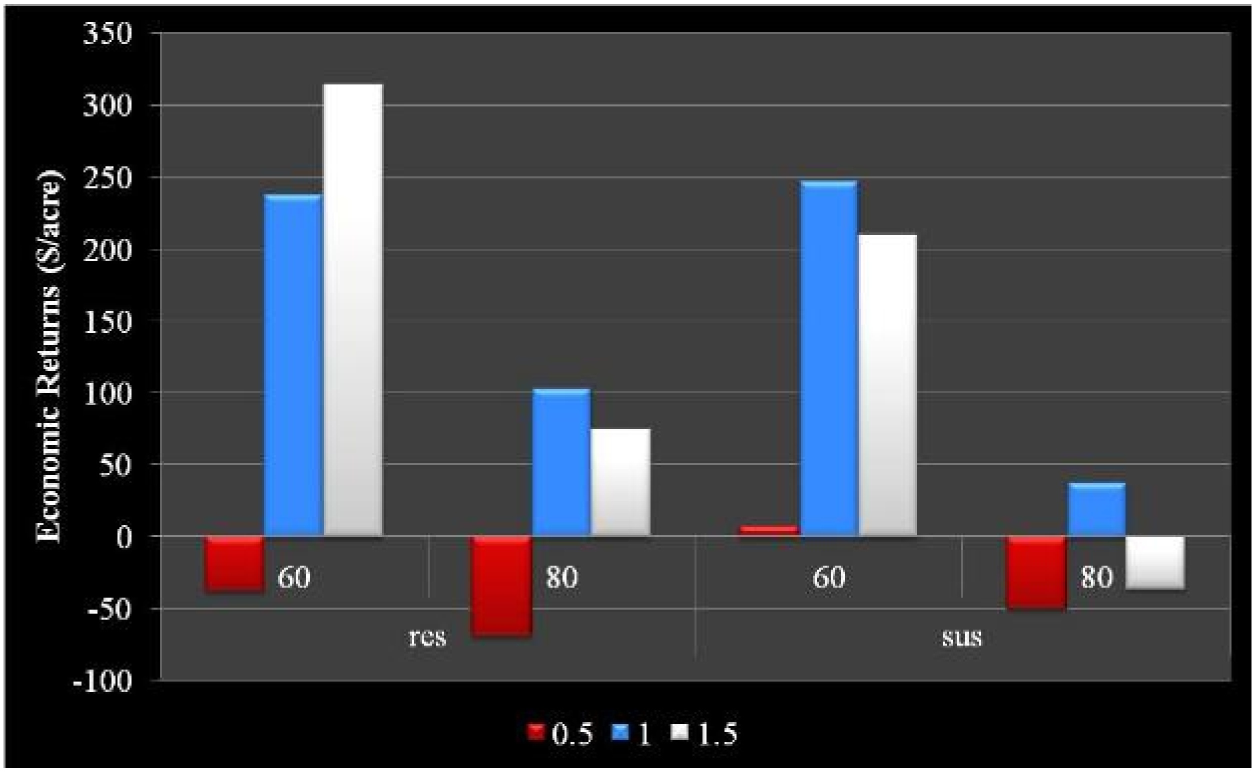

Fig 7. Economic returns of irrigation rates of base (1.0) and base+50% (1.5) and base – 50% (0.5) vs cultivar, where res was a cultivar with partial resistance to Verticillium wilt and sus was a susceptible cultivar. The work was conducted from 2007 – 2009 when the base irrigation rate targeted an evapotranspiration rate (ET) of 80%, and in 2010 and 2012 when the base irrigation rate targeted an ET of 60%.

Summary and Conclusion

In conclusion, a rotated cotton/sorghum system gave better economic returns than continuous cotton. Economic returns with application of 1.0B and 1.5B rates did well when ET=60. Under the wetter conditions (ET=80), 1.0 B had higher returns than 1.5B and 0.5B. At 1.5B and both ET=60 and ET=80, the resistant cultivar returned more than the susceptible cultivar. At 1.0B and ET=80, the resistant cultivar returned more than the susceptible cultivar. And finally at ET=60, the resistant and susceptible cultivar returned similar amounts at 1.0B and at 0.5B. Adjusting cultivar, irrigation level, and ET at the same time is difficult process. West Texas is a semi-arid region so managing available water should be done carefully. Resistant cultivars ($171.38/ac) give better economic returns than susceptible cultivars ($154.58) when the irrigation rate is equal to 60% ET. Adjusting irrigation rate higher than 80% of what the cotton requires will increase the irrigation price and also might reduce production in the field. It is possible that *Verticillium dahliae* will attack cotton severely with high irrigation, as the fungus prefers a cool/wet environment. So, calibrating irrigation to maintain profitable levels requires careful attention and regulation. Under-watering can lead to economic loss, causing the crop to underperform, so under-watering option is the poorest possible choice. Rotated cotton gives higher economic returns however crop rotation requires more equipment and diverse management practices. So, each management option for Verticillium wilt (crop rotation, adjusting irrigation level to an ET of (60 – 80%), and choosing appropriate cultivars led to improved returns, but crop rotation and irrigation adjustments need to be done circumspectly.

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