DP 174 RF, A NEW MID-MATURITY, NEMATODE TOLERANT ROUNDUP READY FLEX VARIETY

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Abstract

Delta and Pine Land has developed a new mid-full maturing picker variety, DP 174 RF, that has shown high yield and fiber quality potential, as well as root knot resistance and reniform tolerance potential. DP 174 RF was developed by Drs. Albert Santos, Don Keim, and Doug Shoemaker at company facilities in Scott, MS. DP 174 RF has medium-tall plant height, hairy leaves, medium seed size and average storm resistant boll type. DP 174 RF exhibits very high gin turnout, very good staple length, strength, micronaire, and uniformity index values. DP 174 RF has shown a potentially wide area of adaptation based on yield and crop value performance in various production areas and systems across the U.S. Cotton Belt. Greenhouse and field studies have shown DP 174 RF to have reduced galling and *Fusarium* wilt highly associated with root knot nematode resistance. Field tolerance studies have shown that DP 174 RF has potentially similar tolerance to root knot nematode as a commercially-available resistant check. Additionally, reniform nematode field tolerance studies have suggested that DP 174 RF may also potentially exhibit tolerance to this nematode species as well.

Introduction

Delta and Pine Land (D&PL) expects to have significant, commercial quantities available of a new mid-full maturing, picker variety containing the Roundup Ready Flex® (RF) transgenic trait. DP 174 RF has exhibited high yield potential, excellent fiber quality potential and agronomic traits that are demanded by growers across a wide geography of the U.S. Cotton Belt.

Materials and Methods

DP 174 RF is the result of the breeding efforts by Drs. Albert Santos, Don Keim, and Doug Shoemaker and their staffs at D&PL research facilities in Scott, MS. The primary selection criteria in the development of DP 174 RF were lint yield, fiber quality, and relative maturity. In 2006, the line designated DPLX06X061F was tested in small-plot replicated D&PL research trials across the U.S. Cotton Belt. In 2007, the line was given a its commercial name and was widely tested across the U.S. Cotton Belt in large-plot, on-farm D&PL agronomic service trials and state university variety trials.

All data reported within are from 2006 D&PL research trials and 2007 D&PL agronomic service trials, D&PL research trials, state university variety trials, and extension county agent trials across the U.S. Cotton Belt, as of 17 December 2007. Yield and fiber quality performance of DP 174 RF will be compared to some of the most popular Roundup Ready® (RR) and RF varieties in the U.S., as well as DP 555 BG/RR, which was the most popular planted variety in 2005, 2006, and 2007 (USDA-AMS, 2005, 2006 and 2007). It will also be compared to key competitor varieties for yield and fiber quality performance. Twenty plants of DP 174 RF and two check varieties were mapped at most of the D&PL agronomic service trial locations in 2007 to determine plant height, node numbers, and maturity (Speed et al., 2004).

Greenhouse trials were conducted at Monsanto Company to determine the number of galls produced following artificial infestation with RKN by Dr. Muhammed A. Bhatti. Each pot was infested with 2,500 eggs. Galls per plant were recorded for several varieties, including DP 174 RF. Data are reported within comparing DP 174 RF to DP 555 BG/RR, Acala Nem-X, and ST 5599 BR.

Data from reniform and RKN screening trials conducted by state university researchers are expressed as tolerance index, which is the ratio of seedcotton yield from untreated plots relative to seedcotton yield from nematicide treated plots (Koenning et al., 2004). Nematicides for these trials ranged from either appropriate rates of aldicarb and/or 1,3-dichloropropene. All seed regardless of treatment were treated with insecticides to protect against early season sucking/piercing insect pests.

Results and Discussion

General Characteristics and Plant Growth

DP 174 RF is a mid-full maturing picker variety with medium-tall plants, and hairy leaves (Table 1). Leaf and stem hairiness is similar to that of DP 432 RR (Speed et al., 2005), but significantly less than that of DP 117 B2RF (Lege' et al., 2006) (data not shown). Seed size ranges from 4,700 to 5,300 per lb. Bolls of DP 174 RF are average in storm resistance, and tolerance of *Fusarium* is very good.

Table 1. Characteristics of DP 174 RF.

Characteristic	*Description or Rating*
Maturity	Mid-Full
Plant Height	Medium-Tall
Leaf Pubescence	Hairy
Range of Seed Size (#/lb.)	4,700 – 5,300
Storm Resistance†	6
Fusarium Tolerance	Very Good

† Rating scale of 1 to 10; 1=loose boll type; 10=high plains type.

Data from 13 locations of D&PL on-farm agronomic service trials indicate that the plant height of DP 174 RF was similar to that of DP 121 RF, but taller than those of DP 147 RF (Table 2). Total nodes and the number of fruiting nodes did not differ among these three varieties. Overall vegetative vigor, as determined by height-to-node ratio, of DP 174 RF was not different than DP 121 RF or DP 147 RF; however, fruiting branch initiation began significantly later for DP 174 RF as compared to DP 121 RF. Similarly, the overall maturity of DP 174 RF was significantly later than that for DP 121 RF, and only numerically later than DP 147 RF.

Table 2. Plant growth and maturity for DP 174 RF versus DP 121 RF and DP 147 RF averaged over 13 on-farm locations of D&PL agronomic service trials across the U.S. Cotton Belt in 2007, as of 17 December 2007.

Variety	*Plant Height (in)*	*Total Nodes*	*Fruiting Nodes*	*Height-to-Node Ratio (in/internode)*	*Node of 1st Fruiting Branch*	*Node of Uppermost Cracked Boll*	*Node of Uppermost Harvestable Boll*	*DD60s to reach 100% open¶*
DP 121 RF	32.6	19.5	9.7	1.68	5.7	10.6	14.4	192
DP 147 RF	30.8	19.8	9.9	1.54	6.0	10.7	14.9	208
DP 174 RF	32.6	20.0	10.0	1.63	6.2	9.9	15.3	266
$LSD_{(0.05)}$†	1.6	ns	ns	0.11	0.4	0.6	0.8	70

† Least significant difference at the alpha=0.05 level; ns=not significant.

¶ Calculated as the number of fruiting nodes between the uppermost cracked boll and the uppermost harvestable boll multiplied by 50 DD60s/node.

Yield and Fiber Quality Performance

DP 174 RF produced significantly higher lint yields than DP 147 RF, but numerically higher yields compared to DP 121 RF, DP 167 RF, DP 432 RR, DP 434 RR, DP 555 BG/RR, and PHY 425 RF, when averaged over the U.S. Cotton Belt (Table 3). DP 174 RF produced similar lint yield compared to ST 5283 RF, but had significantly higher crop value. DP 174 RF also produced significantly higher crop value than DP 147 RF and DP 167 RF. Turnout percentage was significantly higher for DP 174 RF versus all comparison varieties in Table 3, except for DP 555 BG/RR, a variety that exhibits very high turnout (Lege' and Leske, 2003). Staple length for DP 174 RF was significantly longer than DP 121 RF, DP 432 RR and DP 555 BG/RR, but significantly shorter versus DP 147 RF, a variety that has exhibited the production of long fiber (Lege' et al., 2006); however staple lengths of DP 167 RF, DP 434 RR, ST 5283 RF, and PHY 425 RF were not different from DP 174 RF. Fiber strength for DP 174 RF was

significantly greater than DP 432 RR, but significantly less than DP 121 RF, DP 147 RF, and ST 5283 RF. Fiber strength did not differ between DP 174 RF and DP 434 RR and DP 555 BG/RR. Micronaire values were significantly better for DP 174 RF compared to DP 121 RF, but significantly higher compared to DP 147 RF and DP 167 RF. Micronaire values were similar for DP 174 RF versus DP 432 RR, DP 434 RR, DP 555 BG/RR, ST 5283 RF, and PHY 425 RF. Uniformity index values were significantly higher for DP 174 RF compared to DP 555 BG/RR, but significantly lower versus DP 121 RF and DP 432 RR. The remaining varieties had similar uniformity index values relative to DP 174 RF. Loan value was significantly higher for DP 174 RF compared to DP 555 BG/RR, but the remaining varieties had similar loan values versus DP 174 RF.

When averaged over trials conducted in Texas, DP 174 RF had significantly higher lint yield and uniformity index, and numerically higher crop value, turnout, micronaire, and loan value compared to FM 9058 RF (Table 4). Fiber length and strength for DP 174 RF were numerically lower than that for FM 9058 RF.

Table 3. Head-to-head comparisons of DP 174 RF and comparison varieties across the U.S. Cotton Belt in D&PL agronomic service trials (AST), research trials (RES), state university variety trials (OVT), and extension county agent trials (CAT) in 2006-2007, as of 17 December, 2007.

Variety Comparison	*Crop Value*[†] *($/acre)*	*Lbs. lint/ acre*	*% Turnout*	*Staple (1/32 in)*	*Strength (g/tex)*	*Micro-naire*	*% Uni-formity*	*Loan Value*[†] *(¢/lb)*
DP 174 RF	669	1226	39.2	36.3	27.0	4.25	81.7	54.87
DP 121 RF	639	1191	37.9	35.6	28.4	4.41	82.5	53.94
T test[‡]	ns	ns	*	**	***	*	**	ns
No. of tests:	77	96	95	77	77	77	77	77
Year(s): 2007								
State(s): AL, AR, CA, GA, LA, MO, MS, NC, SC, TN, TX and VA								
Datasource(s): AST, OVT and CAT								
DP 174 RF	684	1241	40.5	36.5	27.4	4.31	82.1	54.50
DP 147 RF	592	1094	37.2	37.3	28.6	3.99	81.9	54.44
T test	*	*	***	**	***	***	ns	ns
No. of tests:	93	116	115	93	93	93	93	93
Year(s): 2006-07								
State(s): AL, AR, AZ, CA, GA, LA, MO, MS, NC, OK, SC, TN, TX and VA								
Datasource(s): AST, OVT, CAT and RES								
DP 174 RF	678	1229	42.0	36.7	27.8	4.38	82.5	53.55
DP 167 RF	578	1082	37.6	37.1	29.3	4.19	82.6	53.86
T test	*	ns	***	ns	**	*	ns	ns
No. of tests:	49	69	68	49	49	49	49	49
Year(s): 2006-07								
State(s): AR, AZ, GA, LA, MO, MS, NC, OK, SC, TN, TX and VA								
Datasource(s): AST, OVT, CAT and RES								
DP 174 RF	695	1259	40.9	36.5	27.5	4.38	82.3	53.79
DP 432 RR	626	1173	37.7	35.4	26.7	4.50	83.0	52.70
T test	ns	ns	***	**	**	ns	*	ns
No. of tests:	71	90	90	71	71	71	71	71
Year(s): 2006-07								
State(s): AL, AR, AZ, CA, GA, LA, MO, MS, NC, OK, SC, TN, TX and VA								
Datasource(s): AST, OVT and RES								
DP 174 RF	672	1234	42.2	36.5	27.6	4.40	82.4	53.48
DP 434 RR	620	1168	40.2	36.5	27.5	4.26	82.5	53.74
T test	ns	ns	*	ns	ns	ns	ns	ns
No. of tests:	49	60	60	49	49	49	49	49
Year(s): 2006-07								

State(s): AL, AR, AZ, GA, LA, MS, NC, OK, SC, TX and VA								
Datasource(s): AST, OVT, CAT and RES								
DP 174 RF	695	1242	41.0	36.7	27.8	4.41	82.6	53.98
DP 555 BG/RR	668	1241	40.2	35.2	27.9	4.48	81.4	52.56
T test	ns	ns	ns	***	ns	ns	***	*
No. of tests:	72	89	89	72	72	72	72	72
Year(s): 2006-07								
State(s): AL, AR, AZ, CA, GA, LA, MO, MS, NC, OK, SC, TN, TX and VA								
Datasource(s): AST, OVT and RES								
DP 174 RF	678	1192	44.0	36.1	27.7	4.53	83.0	54.26
ST 5283 RF	669	1194	42.0	35.6	30.9	4.38	83.2	54.28
T test	ns	ns	*	ns	***	ns	ns	ns
No. of tests:	9	37	37	9	9	9	9	9
Year(s): 2007								
State(s): GA, MO, MS, NC, TN, TX and VA								
Datasource(s): AST, OVT and CAT								
DP 174 RF	601	1156	42.7	35.8	27.2	4.27	81.8	52.60
PHY 425 RF	522	1113	38.9	35.3	29.4	4.44	83.3	51.07
T test	ns	ns	***	ns	*	ns	ns	ns
No. of tests:	14	34	33	14	14	14	14	14
Year(s): 2007								
State(s): GA, MO, MS, NC, TN, TX and VA								
Datasource(s): AST, OVT and CAT								

† Based on 2007 USDA CCC loan value of $0.52/lb +/- premiums and discounts, expressed as $/acre gross revenue. Data are means of crop value of individual plots. Base leaf grade, color grade, and uniformity values were used in the crop value calculation for data points for which those data were not reported by the cooperator.
‡ Prob >|t| that values for each variety are not different; *, **, *** indicate significance at alpha = 0.05, 0.01, 0.001, respectively; ns=not significant.

Table 4. Head-to-head comparison of DP 174 RF and FM 9058 RF across Texas in D&PL agronomic service trials (AST) and extension county agent trials (CAT) in 2007, as of 17 December 2007.

Variety Comparison	*Crop Value† ($/acre)*	*Lbs. lint/ acre*	*% Turnout*	*Staple (1/32 in)*	*Strength (g/tex)*	*Micro-naire*	*% Uni-formity*	*Loan Value† (¢/lb)*
DP 174 RF	881	1533	35.3	37.8	27.5	4.29	82.9	57.21
FM 9058 RF	764	1330	33.3	38.2	28.5	4.14	82.0	57.19
T test‡	ns	*	ns	ns	ns	ns	***	ns
No. of tests:	11	11	10	11	11	11	11	11

† Based on 2007 USDA CCC loan value of $0.52/lb +/- premiums and discounts, expressed as $/acre gross revenue. Data are means of crop value of individual plots. Base leaf grade, color grade, and uniformity values were used in the crop value calculation for data points for which those data were not reported by the cooperator.
‡ Prob >|t| that values for each variety are not different; *, **, *** indicate significance at alpha = 0.05, 0.01, 0.001, respectively; ns=not significant.

Yield performance for DP 174 RF was numerically greater than DP 432 RR in irrigated and in dryland trials when averaged over the U.S. Cotton Belt (Table 5). DP 174 RF produced numerically higher yield than DP 555 BG/RR in irrigated trials, but numerically less than DP 555 BG/RR in dryland locations.

Table 5. Head-to-head comparisons for DP 174 RF versus DP 432 RR and versus DP 555 BG/RR in irrigated and in dryland trials across the U.S. Cotton Belt in D&PL agronomic service trials (AST), research trials (RES), state university variety trials (OVT), and extension county agent trials (CAT) in 2006-2007, as of 17 December 2007.

Variety	*Irrigated Trials*	*Dryland Trials*
	----------Lbs. Lint/Acre----------	
DP 174 RF	1520	964
DP 432 RR	1370	946
# locations	46	39
T test†	ns	ns
DP 174 RF	1498	983
DP 555 BG/RR	1453	1022
# locations	44	41
T test	ns	ns

† Prob >|t| that values for each variety are not different; ns=not significant.

DP 174 RF yield performance was above average in production areas from the high plains to the southeast, with exception to the southern southeast, where DP 174 RF yields averaged 1% below trial means (Table 6). Crop value performance for DP 174 RF was 2 to 14% higher than the trial means across the production areas in Table 6. These data indicate that DP 174 RF is potentially adapted across a wide geography within the U.S. Cotton Belt.

Table 6. Lint yield and crop value performance of DP 174 RF relative to individual location trial means in various production areas across the U.S. Cotton Belt in 2006-2007 in D&PL agronomic service trials, research trials, state university variety trials, and extension county agent trials, as of 17 December 2007.

Production Area†	*DP 174 RF Performance (as percentage of individual location means)*‡		*# locations*
	Lint Yield	*Crop Value*	
Northern High Plains	114.0	114.5	6
Southern High Plains	105.8	105.2	21
Rolling Plains	102.7	103.0	6
South Texas	104.5	104.9	8
South Delta	115.2	117.6	17
North Delta	103.2	104.8	33
Southern Southeast	99.0	108.8	29
Northern Southeast	101.5	102.5	16

† Northern High Plains=portions of TX, OK, and KS; Southern High Plains=portions of TX; Rolling Plains=portions of TX and OK; South Texas=lower Rio Grande valley northward to the upper coast of TX; South Delta=southern AR, LA, and southern MS; North Delta=northern AL, northern AR, MO, northern MS, and TN; Southern Southeast=southern AL, FL, GA, and southern SC; Northern Southeast=NC, northern SC, and VA.

‡ Lint yield (lbs/acre) and crop value (based on 2007 USDA CCC loan value of $0.52/lb +/- premiums and discounts, multiplied by lint yield and expressed as $/acre gross revenue) performance of DP 174 RF expressed as a percentage of individual location mean lint yields and crop values, such that tabular values = {[(DP 174 RF performance-mean location performance)/mean location performance]*100}+100.

Potential Nematode Resistance

DP 174 RF was entered into the 2006 National Cotton *Fusarium* Wilt Trial at Tallassee, AL, and exhibited very good resistance to this fungal pathogen (Table 7) that is commonly associated with infestations of root knot nematode (Glass et al., 2007). This field trial showed that DP 174 RF had similar resistance to *Fusarium* wilt as the resistant check, M-315. Additionally, a greenhouse trial conducted at Monsanto Company showed that DP 174 RF was statistically similar to a well-documented root knot resistant variety, Acala Nem-X (Ogallo et al., 1997), with regard to the number of galls recorded per plant (Table 8). These data also indicated that DP 174 RF had numerically fewer galls per plant than a current commercially-available root knot resistant variety, ST 5599 BR (Barfield, 2003). Two studies screening several varieties for field tolerance to root knot nematode did not show any difference among varieties in their tolerance of this pest, indicating that none were statistically different from the tolerant check (Table 9).

Table 7. Percent *Fusarium* wilt ratings for DP 174 RF compared to three sister lines, a susceptible check and a resistant check in the 2006 national *Fusarium* wilt trial at Tallassee, AL. (from Glass et al., 2007)

Entry	***% Fusarium***	***Difference vs. 'M-315' (Prob>F)†***
DP 174 RF	4	ns
Susceptible check ('Rowden')	77	<0.001
Resistant check ('M-315')	1	--

† ns = not significant; significant Prob>F values indicate % *Fusarium* values are statistically different from the resistant check.

Table 8. Galls per plant (least square means) following inoculation with 2,500 root knot (*Meloidogyne incognita*) nematode eggs per pot in a greenhouse study conducted at Monsanto Company in 2007.

Variety	***# replicates***	***# galls per plant***
Acala Nem-X	9	17.2
DP 174 RF	14	40.3
ST 5599 BR	9	50.1
DP 555 BG/RR	18	93.3
$LSD_{(0.05)}$†	--	26.5

† Least significant difference at alpha=0.05.

Table 9. Root knot (*Meloidogyne incognita*) nematode tolerance index of nine varieties averaged over two naturally-infested locations (Dr. Steve Koenning, North Carolina State University, Lenoir Co., NC; and Dr. John Mueller, Clemson University Edisto Research and Education Center, Blackville, SC) in 2007.

Variety	***Tolerance Index†***
DP 515 BG/RR	105.1
DP 161 B2RF	101.3
DP 117 B2RF	100.2
DP 555 BG/RR	100.0
ST 5599 BR	96.2
DP 141 B2RF	94.6
DP 174 RF	92.9
DP 445 BG/RR	90.0
DP 121 RF	81.5
$LSD_{(0.05)}$‡	ns

† Tolerance index = (seedcotton yield of untreated/seedcotton yield of nematicide-treated)*100. (Koenning et al., 2004).

‡ Least significant difference at alpha=0.05; ns=not significant.

Delta and Pine Land breeder trials conducted in 2006 at locations naturally-infested with reniform (*Rotylenchulus reniformis*) nematode showed very good relative yield performance for DP 174 RF (data not shown). In 2007, two field tolerance studies were conducted by university researchers in MS and AL on fields naturally infested with reniform nematode. Averaged over both locations, DP 174 RF had the numerically highest tolerance index of the nine varieties tested, although no statistical differences were detected among the varieties for this parameter (Table 10). Previous studies have suggested significant variability in reniform field tolerance exists among varieties that are currently commercially available, including some listed in Table 10 (e.g., DP 445 BG/RR, DP 515 BG/RR) (Lege' et al., 2007); in these data, DP 174 RF had numerically higher tolerance index compared to the varieties reported to have elevated levels of relative field tolerance in Lege' et al., 2007. Accordingly, further study is warranted to examine the potential field tolerance of DP 174 RF to reniform nematode.

Table 10. Reniform (*Rotylenchulus reniformis*) nematode tolerance index of nine varieties averaged over two naturally-infested locations (Dr. Gabe Sciumbato, Mississippi State University Delta Research and Extension Center, Stoneville, MS; and Dr. Kathy Lawrence, Auburn University, Huxford, AL) in 2007.

Variety	*Tolerance Index*†
DP 174 RF	110.7
DP 515 BG/RR	102.8
DP 141 B2RF	98.7
DP 445 BG/RR	97.3
DP 161 B2RF	93.8
DP 117 B2RF	93.5
DP 121 RF	90.6
ST 5599 BR	89.6
DP 555 BG/RR	86.9
$LSD_{(0.05)}$‡	ns

† Tolerance index = (seedcotton yield of untreated/seedcotton yield of nematicide-treated)*100. (Koenning et al., 2004).

‡ Least significant difference at alpha=0.05; ns=not significant.

Summary

DP 174 RF is a mid-full maturing picker variety that has shown very good yield and fiber quality potential versus several popular and successful comparison and competitor varieties. Additionally, DP 174 RF has shown a potentially wide area of adaptation based on yield and crop value performance in various production areas and systems across the U.S. Cotton Belt. Greenhouse and field studies have shown DP 174 RF to have reduced galling and *Fusarium* wilt highly associated with root knot nematode resistance. Field tolerance studies have shown that DP 174 RF has potentially similar tolerance to root knot nematode as a commercially-available resistant check. Additionally, reniform nematode field tolerance studies have suggested that DP 174 RF may also potentially exhibit field tolerance to this nematode species as well.

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FM 9058 RF is a product of FiberMax/Bayer CropSciences. PHY 425 RF is a product of Dow AgroSciences. ST 5599 BR and ST 5283 RF are products of Stoneville Pedigreed Seed/Bayer CropScience. Acala Nem-X is a product of California Cotton Seed Distributors.

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