Economic Assessment and Fungicide Use on Peanut Seed in the Southwestern United States[1]

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ABSTRACT

Seed protectant fungicides are an important part of a total pest management program of peanut and may reduce the use of other pesticides later in the growing season. A survey of peanut shellers was conducted to determine the amount of fungicide use and the important factors used in selecting particular fungicides for treating seed in the Southwestern United States. All peanut seed planted in Texas, Oklahoma, and New Mexico was treated with one or more fungicides and totaled 19,000 kg of five active ingredients applied on 12 million kg of seed. Captan was the leading active ingredient and made up 49% of all fungicide use. Shellers were the sole decision makers in selecting seed treatment fungicides and cited fungicide effectiveness and assurance of a good crop stand as the major factors in selecting a commercial product. Fungicide treatments made up 4% of the total cost of planting seed, for an average cost of \$6.75/ha. A case study on the impact of seed treatments was conducted using 12 yr of field performance data in an economic assessment. Peanut yields were 36% higher when captan-treated compared with using untreated seed. In an economic assessment, net returns above variable costs were \$331/ha higher when fungicide-treated seed was planted, compared to untreated seed. The case study showed that seed treatments provided positive economic returns in 10 out of the 12 yr and losses would result in 7 out of 12 yr if untreated seed were planted. Many of the present seed treatment fungicides will be reviewed by the U.S. Environmental Protection Agency and require re-registration under the Food Quality Protection Act of 1996.

Key Words: Captan, Food Quality Protection Act, seedling disease, seed treatment fungicides.

An early, vigorous crop stand is essential to obtain a consistent yield of peanut (*Arachis hypogaea* L.). Uniform stands are an important component in peanut production. Growers incur production costs based on hectarage, independent of the plant population. However, net returns and yields are closely related to crop stand. Incomplete stands are one of the most common causes for low yields of peanut (Woodroof, 1966). Causal organisms, disease cycles, and epidemiology of seedling diseases were summarized by Porter *et al.* (1982). Major pathogens that affect peanut seedlings include *Pythium* spp., *Rhizoctonia solani* Kühn, *Fusarium* spp., *Aspergillus niger* van Tieghem, *Macrophomina phaseoli* (Maubl.) Ashby, *Rhizopus* spp., and others which cause damping off and reduce stands or vigor. Seedling diseases cause yield losses of 1 to 2% in Georgia, with state-wide losses averaging \$5.1 million annually (P. Bertrand and T. Brenneman, pers. commun.). They found that yields were reduced up to 18% when untreated seed was planted

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as compared to treated seed. Yield losses were attributed to several factors. With untreated peanut seed, seedling survival was 18% lower, surviving plants showed less vigor, and the incidence of tomato spotted wilt virus (TSWV) was 33% greater.

Woodroof (1966) described the association of diseases with planting seed and the role of a fungicide early in the seedling development process. The peanut seed testa contains tannin-like antioxidants which naturally retard the entrance of pathogens. However, during the shelling process, scratches can occur on the seed coat or the seed coat can detach, which allows organisms to invade and reduce viability if seed are not protected with a fungicide. Fungicide treatments kill pathogens on the seed surface before planting and protect germinating seeds against soil pathogens after planting.

Cultural and nonchemical methods provide some control of seedling diseases. For example, crop rotations are commonly practiced to reduce peanut diseases in Texas and Oklahoma (Smith *et al.*, 1998). Biological control of seedling diseases has been researched (Sherwood *et al.*, 1995). *Trichoderma* spp. and other beneficial antagonists provide some protection against seed pathogens but generally are poor competitors in the soil environment. *Bacillus subtillus* can act as a biological control agent on peanut seed and has some success as a commercial seed treatment (Turner and Backman, 1991).

The use of certified seed treated with a protective fungicide offers the best means for assuring a good crop stand. Phipps and Porter (1998) showed benefits of seed treatments for suppressing fungi. A good stand and early control of seedling diseases are vital for season-long crop production since a poor crop stand may exacerbate pest management efforts later. Davis *et al.* (1995) showed that the incidence of TSWV was several-fold higher in low-density stands of peanut. Insects that vector the virus tend to concentrate on the remaining plants, which results in greater overall damage.

Consistent weed control is essential for profitable peanut production. Buchanan *et al.* (1982) and Henning *et al.* (1982) reviewed several key factors for effective weed management. A poor crop stand and erratic canopy closure reduces the natural suppression of weedy vegetation by the crop. Sunlight penetration through an open crop canopy increases soil temperature and stimulates weed emergence. In addition to yield losses from weed competition, weed foliage can interfere with fungicide coverage on crop foliage and result in harvesting losses. Teasdale and Frank (1983) showed the importance of a dense, uniform crop canopy in reducing weed development in snapbean (*Phaseolus vulgaris* L.). Buchanan and Hauser (1980) illustrated the benefits of increased peanut stands for reducing weed competition. Early uniform formation of a crop canopy potentially reduces the need for postemergence herbicide applications. Dawson (1964) showed that a delay in growth of field bean (*P. vulgaris*) prolonged the necessary period for weed control, since legume crops are poor competitors early, but can suppress weeds later in the season.

Few new seed protectant fungicides have been labeled for use on peanut in the U.S. during the past 20 yr. The future of seed protectant fungicides is somewhat vulnerable in this relatively small commercial market. For example, seed treatment fungicides are applied only once per season, at relatively low rates, and are economically unattractive for commercialization relative to other potential pesticide markets. Most other pesticides are applied at higher rates with potential for multiple applications during the season as pest problems reoccur. Consequently, commercial firms have little economic incentive to develop new fungicides specifically for seed protection.

The Food Quality Protection Act of 1996 (FQPA) directs the U.S. Environmental Protection Agency to review those pesticides that appear to present risks (Goldman, 1997). The Priority Group I pesticide listing includes three fungicides commonly used for treating seed. While pesticide availability in the future will be based on aggregate risk and exposure factors, some economic benefits and alternative control measures for agriculture will be considered.

With pending re-registrations of several fungicides, the purpose of this study was to (a) document the biological benefits of seed protectant fungicides on peanut in current agricultural production, (b) document the quantities of fungicides used and management factors associated with treating seed, and (c) assess the economic benefits of seed treatments for peanut production in the Southwestern U.S.

Materials and Methods

Seed Treatment Tests. Data from 12 field trials conducted between 1982 and 1995 were used to assess the impact of protective fungicides on peanut stand and yield. Each year seed from a commercial lot of peanut (cv. Florunner) was treated with captan (*N*-tricholoromethylthio-4-cyclohexene-1,2-dicarboximide) at the commercial rate of 2.5 g/kg of seed. Treated and untreated seed had germination rates of 85% or higher prior to planting and were planted at the rate of 12 seed/m of row and a depth of 6.4 cm with a cone planter.

Trials were located near Yoakum, TX on a Tremona loamy sand soil that had been planted to peanuts for 15 yr or more. Periodically during the 12-yr period, the presence of *Pythium* spp., *Rhizoctonia* spp., *Fusarium* spp., *Aspergillus* spp., and other pathogens were isolated and confirmed from samples collected in the test area. Each year plots were planted in mid-May to early June and consisted of two rows, 1-m wide by 7.5 m, with treatments arranged in a randomized complete design with four to six replications. Seedlings were counted to determine the percentage of emergence at 4 wk after planting. Plots were harvested 135 to 145 d after planting to determine crop yields. Herbicides and foliar fungicides were applied as necessary to control other pests. Rainfall was supplemented with irrigation as needed to sustain crop growth. Each year data were subjected to an analysis of variance at $P = 0.05$.

Fungicide Use. A survey was conducted with all six members of the Southwestern Peanut Shellers Association to determine fungicide use in treating peanut seed. Collectively, these six firms shell and treat over 89% of the four market types of peanut (runner, spanish, virginia, and valencia) seed planted on 164,000 ha (405,000 acres) in

Texas, Oklahoma, and New Mexico. A mid-level manager or facility operator was interviewed in person or by phone at each of the six southwestern offices in February 1998.

Each firm provided data on seed type and quantities processed in 1997 and the commercial fungicide products and rates applied. We calculated the total quantities of each commercial fungicide formulation by multiplying the weight of each seed type by the application rates for formulation(s) each firm used in treating their seed. The total weights and liquid volumes of the various commercial fungicide products were calculated for each firm and then aggregated for all six firms.

After the total quantities of each commercial formulation were determined, the amounts of each individual active chemical ingredient were calculated. Since commercial formulations contained one to three active ingredients and/or contained the same ingredients but in different concentrations, we followed registrant information on ingredient concentrations to calculate the amounts of the individual active ingredients contained in each product. The amounts of individual active ingredients from each product were then aggregated to obtain totals for the southwestern peanut industry. Both the total kilograms applied and the relative percentage of the fungicide were calculated, as used in the Southwest. Additionally, the percentage of seed treated with each fungicide was determined since some products were applied at low rates but were used widely in the industry. Because proprietary business information was involved, confidentiality was maintained for each participant.

A structured format was followed in asking quantitative and open-ended questions on the decision-making practices associated with the selection and use of seed protectants. Shellers were asked to identify the types of people involved in seed treatment decisions, major factors in selecting fungicides, and the practices in seed treatment, inventory management, and quality control. Quantitative data were tabulated and qualitative responses were summarized in a narrative after all interviews were completed.

Economic Assessments. A cost-benefit study was conducted with irrigated runner-type peanuts since more than 80% of the Southwestern U.S. peanut crop is irrigated and 70% is planted to this market type (Smith *et al.*, 1998). Yields from the 12 yr of fungicide trials (Table 1) provided a long-term basis for peanut performance. Seed treatment and fungicide costs were calculated from survey data provided by shellers. Estimates of production costs and anticipated prices were obtained from Extension Service peanut enterprise budgets (Anon., 1999). Estimates were preharvest production costs at $506/ha, digging costs at $25/ha, combine and drying costs at $0.058/kg, and peanut commodity prices at $0.42/ha or $375/t (as an expected average price for quota and nonquota production). Since only variable costs were involved, this was a partial budget analysis based on the outcomes of using fungicide-treated seed. The initial budget analysis did not include the fixed costs, such as capital, depreciation, or taxes commonly included in a total farm enterprise assessment.

Results and Discussion

Seed Treatment Tests. In the 12-yr comparison of untreated and fungicide-treated seed, crop emergence ranged from 45 to 90% and averaged 66% or eight plants/m of row when seed were treated with a commercial fungicide containing captan (data not shown). With untreated seed, seedling emergence ranged from 22 to 80% and averaged 41% or five seedlings/m of row over the same 12 yr. Seedling emergence from treated seed was consistently and significantly higher in every study compared to untreated seed. Many of the stands from untreated seed resulted in fewer than six seedlings/m of row and would have been unacceptable for commercial peanut production. Marginal crop stands can result in increased weed problems and subsequently cause increased costs and problems in peanut production (Buchanan *et al.*, 1982).

Table 1. Yields of Florunner peanut grown from untreated seed and seed treated with captan between 1982 and 1995 at Yoakum, TX.

	Peanut yield		
Year	Untreated	Captan	Increase due to seed treatment
	--------kg pods/ha[a] -----		%
1982	2970 a	3740 b	26
1983	3060 a	3670 b	20
1984	1620 a	2810 b	73
1985	3080 a	4360 b	41
1986	1880 a	2130 b	13
1987	1920 a	2980 b	55
1990	2800 a	4140 b	48
1991	3620 a	5410 b	49
1992	2780 a	3490 b	25
1993	2820 a	3770 b	33
1994	2940 a	3970 b	35
1995	1930 a	2470 b	28
12-yr avg	2620	3580	37

[a]Means in the same row followed by the same letter are not significantly different (P = 0.05).

The benefits of using fungicide-treated seed were most apparent at harvest. Yields were significantly higher in every study where treated seed was planted (Table 1). Where a protective fungicide was used, yields averaged 3580 kg/ha, which was 37% higher than yields obtained from untreated seed.

Fungicide Use. Shellers processed and bagged 12 × 10^6 kg of seed in 1997, which consisted of 70% runner, 17% spanish, 10% virginia, and 3% valencia types for the southwestern region. One hundred percent of the seed was treated with one or more protective fungicides. Commercial fungicides, in order of usage, were Vitavax PC + Topsin, Thiram, PCNB, and Vitavax PC. Each of these commercial formulations contained one or more active ingredients. Most seed was treated with one commercial product which contained multiple fungicides. Hence, each seed lot was protected with more than one fungicidal ingredient. A total of 19,170 kg of fungicide of five active ingredients was applied to 12 × 10^6 kg of seed peanut in 1997 (Table 2).

Captan was the dominant active ingredient applied to seed peanut; nearly 9400 kg was utilized and accounted for 49% of all fungicide use in the Southwest. Captan is

Table 2. Fungicides applied to peanut planting seed in the Southwestern U. S. in 1997.

Active ingredient	Fungicide use		Seed treated with fungicide
	kg applied	% of total	%
Captan	9380	49	90
PCNB	3760	20	92
Thiophanate methyl	3080	16	89
Carboxin	2090	11	90
Thiram	860	4	7
Total	19,170	100	100

Table 3. Participants and factors in the selection of protective fungicides for seed peanut.

	% time cited
Key decision makers in the selection of fungicides	
Sheller/seedsman	100
Regional seed or field representative	33
Farmer	0
Key factors in the selection of fungicides	
Fungicide known to be effective for seedling diseases	100
Need to assure seedling protection for a good stand	100
Research or extension advice on new problems	17
Fungicide and application costs	0

the major ingredient in Vitavax PC formulations and was applied to 90% of all planting seed. Captan provides protection against the major seedling pathogens found in peanut; however, the re-registration and continued use of captan for many agricultural applications is subject to review under the FQPA as a suspected B2 carcinogen in Priority Group I (Goldman, 1997).

PCNB (pentachloronitrobenzene), also contained in Vitavax PC formulations, was the second most abundant fungicide ingredient. Approximately 3800 kg of PCNB was applied, which made up 20% of the total volume of fungicide. This fungicide was used by all shellers and was applied to 92% of all seed.

Thiophanate methyl {dimethyl[(1,2-phenylene)-bis(iminocarbonothioyl)]bis(carbamate)} use totaled 3080 kg and comprised 16% of the total quantity of fungicide. Thiophanate methyl, formulated as Topsin, was applied to 89% of all seed and is only labeled use in Texas and Oklahoma. This fungicide is the only labeled product that will reduce the seed-borne transmission of *Sclerotinia* spp. in peanut seed (Melouk, 1992) and will be reviewed as a methylbenzimidizolyl carbamate under the FQPA (Goldman, 1997).

Carboxin (5,6-dihydro-2-methyl-*N*-phenyl-1,4,oxa-thiin-3-carboxamide) is the fourth most prevalent fungicide. Use totaled nearly 2100 kg, which represented 11% of the total quantity of fungicide used in the Southwest. While this fungicide was applied at low rates, it was applied to 90% of the seed. Less than 1000 kg of thiram (tetramethylthiuram disulfide) was used and made up 4% of the total active ingredients. Thiram was applied on 7% of the seed in the Southwest and will be reviewed as a Priority I pesticide under the FQPA. Carboxin is not scheduled for review under FQPA.

Fungicide Selection and Management Practices. Shellers were the sole decision-makers in the selection of the protective fungicides to be used for treating seed (Table 3). Some regional field managers provided feedback to shellers on seed performance in the field. Farmers were not involved in the choice of fungicides and reportedly depended on the sheller/seed processor to select appropriate treatments. Shellers did not alter their choice of fungicide or application rates based on eventual market sites or geographic destinations of seed. Firms reported that limiting the use to only one or two commercial fungicides for all seed circumvented potential seed inventory and management problems.

When queried on the key factors in selecting a particular fungicide, shellers reported that their choices were based on two considerations (Table 3)—an effective treatment for controlling seedling diseases and seed protection—to assure a good crop stand. Shellers indicated that farmers expected them to select and offer the best available commercial seed treatments.

Shellers relied upon research and Extension Service personnel for periodic advice on new diseases and control measures. One example mentioned was the demonstrated benefits of thiophanate methyl in reducing seed-borne transmission of *Sclerotinia* blight (Melouk, 1992). There were no indications that fungicide cost was a major factor in the preferential selection of a particular product.

Several quality assurance and cost control practices were mentioned by shellers. All shellers conducted a germination test on untreated seed to avoid treating low-quality seed. Firms estimated seed demand annually but only treated shelled seed after orders were received. Inventories of treated seed were not maintained in anticipation of sales since treated seed could not be used for other purposes.

All firms reported that fungicides were applied with mechanical equipment specifically designed to dispense formulated products at prescribed rates. Application equipment was reported to be checked or calibrated daily. Fungicide application was supervised by a certified non-commercial pesticide applicator employed by each firm. All fungicides included a binding agent to assure good adhesion to the seed and a dye of an unnatural color to easily distinguish treated seed from seed destined for other end uses.

Economic Assessment and Case Study. Shellers estimated that a fungicide and application added $1.50 to $2 to the cost of a 22.7-kg (50-lb) bag of planting seed. The average cost was $1.70 /bag. The total cost of seed quoted by shellers averaged $42.60/bag. Based on these figures, the fungicide treatment cost $.075/kg of seed or 4% of the total price. Since runner-type peanuts are usually seeded at the rate of 90 kg/ha (Anon., 1999), the fungicide seed treatment was calculated to be $6.75/ha. The purchase of untreated planting seed is not an option in the commercial market place. However, the 4% cost for a fungicide treatment is nominal when considering a total cost of $168/ha for seed and a total cost of $506/ha in peanut production (Anon., 1999).

Recent commercial development of transgenic seed of several crops has resulted in more costly seed as a result of technology use fees. With expanded use of transgenic technologies anticipated in the future, the use of protective fungicides will be increasingly important to protect this higher-priced seed and thus realize its full genetic potential in the field.

The case study considered the economics of using fungicide-treated seed. The lowest, highest, and 12-yr average yields of runner peanut (Table 1) were used along with crop production costs and expected prices in the Southwestern U.S. (Anon., 1999) to calculate economic impacts (Table 4).

Gross returns across the 12-yr period averaged $1074/ha using untreated seed and $1468/ha using treated seed—a $394/ha advantage when treated seed were planted (Table 4). However, a more realistic economic assessment was obtained when preharvest production costs and yield-related harvesting expenses were considered for the two seed treatments.

Preharvest production costs of $499 and $506/ha were deducted from the gross returns from untreated and treated seed, respectively. These production costs gave favorable consideration to a possible savings of $7/ha if untreated seed were used but did not impose any additional costs that might be incurred for increased disease and weed problems if poor crop stands resulted. Additionally, harvest-related costs of digging, combining, and drying were deducted from gross returns to assess the net returns for the various seed treatment scenarios (Table 4).

Net returns above variable costs ranged from $46/ha from the lowest yield from untreated seed in the 12-yr period to a maximum of $1373/ha from the highest yield when treated seed were planted. The 12-yr average returns were $398/ha for untreated seed and $729/ha from treated seed. The $331/ha difference between the two treatments clearly demonstrates why all planting seed is treated and these crop protection chemicals are essential to sustain commercial production.

In a final assessment of fungicide use, the total costs of crop production were considered. Crop budgets for producing irrigated runner peanut include an additional $583/ha for the fixed costs of capital, equipment, depreciation, and taxes in the farm enterprise. When these fixed expenses were deducted from net variable returns in the seed treatment case study, the net returns (returns to management) were negative in 7 of the 12 yr in using untreated seed with an average loss of $185/ha (data not shown). However, when these same fixed expenses were deducted when using treated seed, the true net returns to growers remained positive in 10 of the 12 yr and gave an average return of $146/ha. This case study and economic assessment clearly show that protective fungicides for planting seed are essential to sustain any scenario for profitable peanut production in the Southwestern U.S.

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Table 4. Economic assessment of using fungicide-treated planting seed in the production of irrigated runner peanut in Texas.

Economic variable		Untreated seed			Treated seed		
Component	Unit	Lowest	Highest	Avg	Lowest	Highest	Avg
Yield[a]	kg/ha	1620	3620	2620	2130	5410	3580
Gross returns[b]	$/ha	664	1484	1074	873	2218	1468
Less variable costs:[c]							
Pre-harvest	$/ha	499	499	499	506	506	506
Digging	$/ha	25	25	25	25	25	25
Combine & drying	$/kg	94	210	152	124	314	208
Net variable returns[d]	$/ha	46	750	398	218	1373	729

[a]Based on yields from seed treatment studies conducted in 1982 to 1995 at Yoakum, TX.

[b]Gross returns were based on $0.41/kg ($375/t) for peanut yields.

[c]Variable costs were obtained from Extension Service crop enterprise budgets for peanut production in west Texas.

[d]Net returns above variable costs; does not include fixed costs for capital, taxes, or depreciation.

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