We are IntechOpen, the world’s leading publisher of Open Access books
Built by scientists, for scientists

3,800
Open access books available

116,000
International authors and editors

120M
Downloads

154
Countries delivered to

TOP 1%
Our authors are among the most cited scientists

12.2%
Contributors from top 500 universities

WEB OF SCIENCE™
Selection of our books indexed in the Book Citation Index in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected. For more information visit www.intechopen.com
Defining Interactions of Herbicides with Other Agrochemicals Applied to Peanut

David L. Jordan, Professor
Gurinderbir S. Chahal, Graduate Research Assistant
Sarah H. Lancaster, Former Graduate Research Assistant
Joshua B. Beam, Former Graduate Research Assistant
Alan C. York, William Neal Reynolds Professor Emeritus

1Department of Crop Science, North Carolina State University, Box 7620, Raleigh, NC 27695-7620.
2Department of Crop Science, North Carolina State University, Box 7620, Raleigh, NC 27695-7620.
3Department of Crop Science, North Carolina State University, Box 7620, Raleigh, NC 27695-7620.

Current position: Assistant Professor, Department of Plant and Soil Sciences, Oklahoma State University, 368 Agricultural Hall, Stillwater, OK 74078-6028.

4Department of Crop Science, North Carolina State University, Box 7620, Raleigh, NC 27695-7620.


5Department of Crop Science, North Carolina State University, Box 7620, Raleigh, NC 27695-7620.

United States of America

1. Introduction

Management strategies to protect peanut (Arachis hypogaea L.) from pest damage require multiple applications of fungicides, herbicides, and insecticides. Additionally, micronutrients and plant growth regulators are often applied to improve nutrient balance and to manage peanut growth and development. Over fifty active ingredients can be used to manage pests in peanut, often with more than one formulated product commercially available. Timing of application of pesticides, micronutrients, and plant growth regulators often coincide during the growing season, and co-application of these agrochemicals is desirable if pesticide, micronutrient, and plant growth regulator performance and peanut tolerance are not compromised. In addition to potential interactions related to physiological effects on plants and other organisms, application variables such as commercial formulation, adjuvant, water quality, and environmental stress can affect agrochemical compatibility.
Physical compatibility, in particular formation of precipitates in spray tanks and equipment, is a concern for farmers when co-applying agrochemicals. Defining potential interactions among these agrochemicals is important in developing appropriate weed management programs and implementing integrated pest management strategies for peanut. Considerable research has been conducted during the last four decades to define interactions among agrochemicals (Barrett, 1993; Green, 1989; Green and Bailey, 1987; Hatzios and Penner, 1985; Putnam and Penner, 1974). Most of these reviews are focused on interactions of herbicides in mixture with other herbicides, fungicides, insecticides, nematicides, and adjuvants, in general, but not for a particular crop. Some of these reviews summarized the mechanisms responsible for the interactions of herbicides with other agrochemicals and the statistical methodology for characterization of agrochemical combinations (Barrett, 1993; Green, 1989; Hatzios and Penner, 1985; Jianhua et al., 1995). Since these reviews were published, many of new agrochemicals have received registration for different crops and for other uses. Defining interactions of these new agrochemicals is important when developing pest management strategies for a cropping system. This chapter reviews some of the interactions discussed in the earlier work, but also elucidates the interactions and/or compatibility of herbicides with other agrochemicals used in peanut production systems.

2. Peanut production systems

Mechanized production systems utilize a wide range of agrochemicals to manage peanut growth and development and minimize the impact of pests on peanut yield and quality (Lynch and Mack, 1995; Sherwood et al., 1995; Wilcut et al., 1995). Pests that can potentially impact peanut are diverse (Table 1). Yield loss from weed interference or from damage caused by insects, diseases, and nematodes can be substantial in peanut if pest control strategies are not implemented in a timely manner. Monocotyledonous weeds, including annual and perennial grasses and sedges, as well dicotyledonous weeds, are prevalent in peanut production systems in the United States (Webster, 2009; Wilcut et al., 1995). Comprehensive herbicide programs, in combination with appropriate cultural practices, are employed to manage weeds and minimize interference and subsequent yield loss (Wilcut et al., 1987a, 1987b, 1990, 1995). Herbicides are often applied in mixtures either prior to planting (preplant incorporated in conventional tillage or preplant to emerged weeds in reduced tillage), immediately following planting (preemergence), or after peanut and weeds have emerged (postemergence) (Burke et al., 2004; Clewes et al., 2007; Richburg et al., 1995, 1996; Wilcut et al., 1994a, 1994b, 1995). Agrochemicals with efficacy against insects and plant parasitic nematodes are often applied in the seed furrow at planting and include organophosphate and carbamate insecticides (Brecke et al., 1996; Drake et al., 2009; Funderburk et al., 1998; Minton et al., 1990; Minton and Morgan, 1974; Riley et al., 1997). In-furrow insecticides also reduce incidence of tomato spotted wilt of peanut (caused by tomato spotted wilt virus, a Tospovirus vectored by several species of thrips) (Brown et al., 2003; Hurt et al., 2003). Pyrethroid insecticides are often applied to peanut foliage to control beet armyworm, corn earworm, fall armyworm, potato leaf hopper, and two-spotted spider mites. Chlorpyrifos can be applied at pegging, 45 to 70 days after peanut emergence, to control lesser cornstalk borer (Mack et al., 1989, 1991) and southern corn rootworm (Brandenburg and Herbert, 1991; Chapin and Thomas, 1993).
Depending on environmental and edaphic conditions and a range of agronomic and pest management practices, application of insecticides may be needed throughout the growing season to protect peanut from pest damage. Disease, caused by viruses, bacteria, or fungi, can reduce peanut yield considerably when not controlled (Sherwood et al., 1995). Fungicides are applied routinely to peanut to control foliar-borne diseases, including early leaf spot, late leaf spot, and web blotch (Brenneman et al., 1994; Culbreath et al., 2008; Shew and Waliyar, 2005). Fungicides are also applied to control the soil-borne disease stem rot and Sclerotinia blight (Brenneman et al., 1994; Culbreath et al., 2008; Smith et al., 1992). Although variation is noted among geographical regions, years, and environmental conditions, during a typical growing season fungicides are applied either singly or in combination beginning approximately 45 days after peanut emergence and continuing throughout the remainder of the growing season, which can approach 135 or more days (Sherwood et al., 1995; Smith and Littrell, 1980). Fungicide programs to control early and late leaf spot and stem rot often include bi-weekly sprays during this period. Fungicides applied to control these diseases provide protection for a period of two weeks under most environmental conditions (Shew and Waliyar, 2005). The soil fumigant metam sodium is often applied to peanut to control Cylindrocladium black rot (Cline and Beute, 1986). A period of at least two weeks between fumigation and peanut planting is required to allow the fumigant to dissipate, making weed control prior to planting challenging under some environmental conditions, especially excessive rainfall, that allow weeds to emerge between fumigation and planting operations (Van Gundy and McKeny, 1977).

The micronutrients boron and manganese are applied routinely to optimize peanut growth and development and, in the case of boron, to ensure proper kernel development (Gascho and Davis, 1995; Harris and Brolman, 1966; Powell et al., 1996). Because peanut is often grown on coarse-textured soils, boron can be deficient due to leaching. Single, and in some cases, multiple applications of boron-containing foliar solutions are applied 45 to 70 days after peanut emergence (Gascho and Davis, 1995). Manganese deficiency occurs frequently in peanut because of liming to achieve a target soil pH above 6.0. Correcting a manganese deficiency is achieved by foliar applications when visible symptoms become apparent, although some growers apply manganese irrespective of plant symptomology (Powell et al., 1996).

Excessive vine growth of peanut can reduce row visibility at digging and vine inversion (Mitchem et al., 1996). Prohexadione calcium is currently the only plant growth regulator applied to manage vine growth in order to facilitate efficient digging. Prohexadione calcium inhibits gibberellin biosynthesis in responsive plants (Grossman et al., 1994) and is applied when 50% of vines from adjacent peanut rows have met, and an application is repeated 2 to 3 weeks later (Mitchem et al., 1996). This timing of application is generally 70 to 90 days after peanut emergence (Mitchem et al., 1996). In addition to prohexadione calcium, a wide range of products are available at the distributor level that contain micronutrient combinations, synthetic plant growth regulators, and other ingredients perceived to have value. Many of these products are not applied routinely to peanut.

3. Agrochemicals used in peanut

A diversity of pesticide active ingredients is available for peanut (Table 2) (Brandenburg, 2010; Jordan, 2010; Shew, 2010). Currently, 19 herbicide active ingredients, 16 insecticide
active ingredients, and 20 fungicide active ingredients representing the major modes of action can be applied during the peanut growing season. Three fumigants, two micronutrients, and one plant growth regulator are registered for use in peanut. Within herbicide, insecticide, fungicide, and fumigant categories, a range of formulated products are available for most active ingredients. These products are often manufactured and sold through distributor networks and are numerous. Additionally, spray adjuvants are recommended with some, but not all, agrochemicals to increase performance and compatibility.

Presence of biotic and abiotic stresses often occur simultaneously during the peanut growing season, and timing of application for many agrochemicals overlap (Table 3). Practitioners prefer limiting the number of trips across fields in order to increase efficiency of managing peanut. This approach is preferable because of convenience, savings in time, reduced application costs, and freeing labor for other operations. Additionally, applying multiple pesticides with different modes of action is an important resistance management strategy for pests (Brandenburg, 2010; Jordan, 2010; Shew, 2010). This approach is feasible as long as adverse interactions, primary increased crop injury or decreased pest control, do not occur. Defining interactions among agrochemicals is important in assisting growers and their advisors as they make decisions on co-application of these products.

4. Herbicide – Herbicide interactions

A considerable amount of research has been conducted to define interactions among herbicides used in peanut. Herbicides applied in combination either preplant incorporated or preemergence generally increase the spectrum of weed control or the length of residual weed control (Wilcut et al., 1987b 1995). For example, pendimethalin is often applied in combination with alachlor, dimethenamid-P, metolachlor, or S-metolachlor to improve early season weed control (Bridges et al., 1984; Wehtje et al., 1988; Wilcut et al., 1994b 1995; Wilcut and Swann, 1990). Alachlor, dimethenamid-P, metolachlor, or S-metolachlor can be applied with diclosulam, flumioxazin, or imazethapyr preemergence to enhance weed control with a single application (Clewis et al., 2007; Grichar et al., 1992, 1996, 2000, 2008; Scott et al., 2001). Combinations of preplant incorporated or preemergence herbicides currently registered for use in peanut have not been shown to increase peanut injury over either herbicide component applied alone (Wilcut et al., 1995). However, several herbicides that are no longer registered for peanut increased peanut injury when co-applied as compared to the herbicides applied alone (Wilcut et al., 1995).

In reduced tillage systems, herbicides are needed to control winter weeds and summer annual weeds that have emerged prior to planting peanut. These herbicide applications include glyphosate, paraquat, or 2,4-D alone or in combinations with other herbicides. Combinations of glyphosate and 2,4-D broaden the spectrum of weed control compared with each herbicide applied alone (Flint and Barrett, 1989a). However, in some instances, 2,4-D can negatively affect efficacy of glyphosate, but this interaction is typically noted only on grass weeds (Flint and Barrett, 1989b). Efficacy of paraquat is generally not negatively affected by 2,4-DB (Wehtje et al., 1992a). Glyphosate and paraquat can also be applied with herbicides that provide residual weed control. This approach is designed to control emerged weeds and provide residual weed control prior to and following planting (Wilcut et al., 1995).
Paraquat is often applied at peanut emergence or up to 28 days after peanut emergence (Carley et al., 2009; Wilcut et al., 1990). Other non-residual herbicides such as bentazon or acifluorfen plus bentazon as well as residual herbicides such as alachlor, diclosulam, dimethenamid-P, imazethapyr, metolachlor, or S-metolachlor are applied postemergence to broaden the spectrum of control (Askew et al., 1999; Bailey et al., 1999; Grey et al., 2002; Grichar and Colburn, 1996). Injury associated with paraquat can be reduced by co-application with bentazon (Jordan et al., 2003b; Wehtje et al., 1992b). However, the chloroacetamide herbicides alachlor, dimethenamid-P, metolachlor, or S-metolachlor applied with paraquat can increase peanut injury (Jordan et al., 2003b). Diclosulam and imazethapyr did not affect injury potential from paraquat (Jordan et al., 2003b). Weed control with these herbicide combinations generally increases depending on the weed species and size of the weed (Wilcut et al., 1995). For example, bentazon and imazethapyr co-applied can increase control of emerged common cocklebur and yellow nutsedge, while control of annual grasses by paraquat can be reduced when paraquat is co-applied with bentazon (Wehtje et al., 1992b; Wilcut et al., 1994b). Residual control by chloroacetamide herbicides, diclosulam, and imazethapyr was not affected by paraquat applied alone or with bentazon (Grichar et al., 2000; Wilcut et al., 1995).

Co-application of postemergence herbicides with efficacy against dicotyledonous weeds and sedges generally increases control of weeds or broadens the spectrum of control compared with components of the mixture applied alone (Green, 1989; Hatzios and Penner, 1985; Jianhua et al., 1995; Wilcut et al., 1995). In contrast, efficacy of clethodim and sethoxydim, often referred to as graminicides, can be reduced when applied in mixture with herbicides that control dicotyledonous weeds and sedges (Culpepper et al., 1998 1999; Grichar, 1991; Jordan and York, 1989; Minton et al., 1989; Mueller et al., 1989; Myers and Coble, 1992; Vidrine et al., 1995). The interaction of bentazon and sethoxydim is one of the most notable examples of reduced graminicide efficacy caused by a herbicide that controls dicotyledonous plants and sedges (Rhodes and Coble, 1984a 1984b; Wanamarta and Penner, 1989; Wanamarta et al., 1989). Annual and perennial grass control by sethoxydim is reduced by bentazon through reduced absorption of sethoxydim into grasses (Rhodes and Coble, 1984b; Wanamarta and Penner, 1989; Wanamarta et al., 1989). The mechanism of reduced control is associated with physical interactions of the herbicides in the spray solution prior to reaching the target weed (Penner, 1989; Thelen et al., 1995). Acifluorfen and imazethapyr also can reduce efficacy of clethodim and sethoxydim (Burke and Wilcut, 2003; Grichar, 1991; Lassiter and Coble, 1987; Myers and Coble, 1992). In contrast to reduced grass control when these herbicides are co-applied, control of dicotyledonous plants and sedges is not reduced by clethodim and sethoxydim (Dotray et al., 1993; Holshouser and Coble, 1990; Isaacs et al., 2003). Efficacy of clethodim can also be reduced by acifluorfen, acifluorfen plus bentazon, bentazon, imazethapyr, imazapic, lactofen, and 2,4-DB (Grichar et al., 2002; Myers and Coble, 1992; York et al., 1993). The magnitude of reduced efficacy can be minimized or eliminated by applying the herbicides sequentially, increasing the graminicide rate, or applying more efficacious adjuvants (Burke et al., 2004; Jordan, 1995; Myers and Coble, 1992; Wanamarta and Penner, 1989; Wanamarta et al., 1989). Grass species, plant size, and plant stress also can affect the magnitude of negative interactions (Green, 1989; Hatterman-Valenti et al., 2006). York and Wilcut (1995) reported that bentazon reduced control of yellow and purple nutsedge by imazethapyr.
Chloroacetamide herbicides can be applied postemergence without injuring peanut (Grichar et al., 1996, 2008; Jordan et al., 2003b). While these herbicides provide residual control of grasses and some dicotyledonous and sedge weeds, they do not control weeds that have emerged (Foy and Witt, 1997; Grichar et al., 2000; Richburg et al., 1995). These herbicides can be applied with herbicides that have efficacy against emerged weeds. Dimethenamid-P and S-metolachlor did not reduce grass control by the graminicides clethodim or sethoxydim or the dicotyledonous and sedge herbicides acifluorfen, acifluorfen plus bentazon, or imazapic (Grichar et al., 2000; Wilcut et al., 1995). However, visible injury caused by acifluorfen increased when acifluorfen was applied with chloroacetamide herbicides (Jordan et al., 2003b). Johnson et al. (1993) reported that injury from postemergence application of paraquat was not increased when following several chloroacetamide herbicides applied at planting, in contrast with injury observed when the herbicides were co-applied.

5. Herbicide – Insecticide interactions

Timing of application of herbicides and insecticides overlap during much of the growth cycle of peanut (Table 3). As with other crops, potential interactions between herbicides and insecticides applied in the seed furrow to control thrips and suppress plant parasitic nematodes can occur (Hauser et al., 1976, 1981). Acephate and aldicarb applied in the seed furrow at planting did not affect injury potential of peanut following postemergence application of acifluorfen plus bentazon or bentazon; however, the insecticide phorate applied in the seed furrow enhanced visible injury associated with bentazon, although this injury was generally transient (Swann and Herbert, 1999). Although interactions of nicosulfuron (Bailey and Kapusta, 1994; Morton et al., 1994; Rahman and James, 1993) and pyrithiobac-sodium (Allen and Snipes, 1995) increased injury in corn (Zea mays L.) and cotton (Gossypium hirsutum L.), respectively. However, chlorpyrifos applied at planting did not affect peanut response to diclosulam, S-metolachlor, or fluoxfloxin applied preemergence or acifluorfen, acifluorfen plus bentazon, imazapic, or paraquat plus bentazon applied postemergence (Jordan et al., 2008). Efficacy of graminicides can be affected by insecticides applied to peanut. Carbaryl and dimethoate applied postemergence in combination with sethoxydim reduced annual grass control; no adverse effect was noted when acephate was mixed with sethoxydim (Byrd and York, 1988). Pyrethroid insecticides did not affect efficacy of postemergence herbicides (Allen and Snipes, 1995).

6. Herbicide – Fungicide interactions

Similar to herbicides and insecticides, timing of application of postemergence herbicides and fungicides to control foliar and soil-borne diseases overlap considerably during the peanut growing season (Table 3). Fungicides are applied beginning approximately 45 days after peanut emergence and can be applied until a few weeks prior to digging and vine inversion. Efficacy of clethodim and sethoxydim can be reduced by co-application with copper-containing fungicides or azoxystrobin, chlorothalonil, and pyraclostrobin (Jordan et al., 2003a; Lancaster et al., 2005a 2008). Fluazinam and tebuconazole did not reduce grass control compared with graminicides applied alone (Jordan et al., 2003a; Lancaster et al., 2005a 2005b). Efficacy of herbicides that control dicotyledonous and sedge weeds is not generally
affected by fungicides (Jordan et al., 2003a). As was noted for interactions of herbicides, weed species and size and plant stress can affect the magnitude of interactions between herbicides and fungicides (Jordan et al., 2003a).

Although not used in peanut, efficacy of glyphosate was not affected by azoxystrobin, pyraclostrobin, or tebuconazole (Grichar and Prostko, 2009). Weed control by metribuzin, rimsulfuron, and thifensulfuron-methyl applied to tomato (Lycopersicon esculentum Mill.) was not affected by azoxystrobin or pyraclostrobin (Robinson and Nurse, 2008). However, pyraclostrobin increased tomato injury from thifensulfuron-methyl when co-applied (Robinson and Nurse, 2008). Chlorothalonil increased persistence of metolachlor in soil although cyproconazole, flutriafol, and tebuconazole did not affect dissipation of metolachlor (White et al., 2009).

7. Herbicide – Micronutrient interactions

Boron and manganese are the primary micronutrients applied to peanut. Occasionally, these can affect herbicide performance. For example, efficacy of clethodim and imazethapyr was reduced by micronutrients for some, but not all, weeds evaluated (Jordan et al., 2006; Lancaster et al., 2005b).

8. Herbicide – Plant growth regulator interactions

Prohexadione calcium is the primary plant growth regulator available for use in peanut. Efficacy of the herbicides acifluorfen, acifluorfen plus bentazon, bentazon, imazethapyr, imazapic, lactofen, and 2,4-DB was not affected by prohexadione calcium (Beam et al., 2002). However, other plant growth regulator products developed by agrochemical distributor chains are numerous and have not been evaluated sufficiently to make recommendations on compatibility with herbicides.

9. Co-application of multiple components

The previous discussion focused on co-applications that have only two components. However, there is considerable interest in compatibility of three or more pesticides, micronutrients, adjuvants, or plant growth regulators and their impact on pest control and crop management. With respect to weed control, efficacy of clethodim, sethoxydim, and 2,4-DB were compared when these herbicides were applied alone or with fungicides and insecticides (Jordan et al., 2003a; Lancaster et al., 2005a 2005b). Although results often supported previous findings with components from two groups of pesticides, no clear relationships were established with respect to combinations of three or more pesticides (Lancaster et al., 2005a 2005b). More recently, research is being conducted to compare herbicide efficacy with mixtures containing various levels of fungicide, insecticide, micronutrient, or adjuvant (Chahal et al., 2009a 2009b).

10. Herbicide effects on other agrochemicals

The focus of this review has been the impact of agrochemicals used in peanut on herbicide efficacy. However, defining the impact of herbicides on insect and disease control and
response of peanut to micronutrient and plant growth regulator applications is important. Preliminary research has shown that the herbicides clethodim and 2,4-DB do not affect performance of chlorothalonil, pyraclostrobin, or the prepackage combination of prothioconazole plus tebuconazole (Chahal et al., 2009a, 2009b). Paraquat and 2,4-DB did not affect chlorothalonil efficacy (Choate et al., 1998). Katon and Eshel (1973) discussed possible mechanisms of interactions among herbicides and pathogens. With respect to peanut, Baysinger et al. (1999) reported that sporulation of early leaf spot was reduced by acifluorfen and lactofen. In-vitro, chlorothalonil efficacy against early blight (Alternaria solani) was reduced by metribuzin while susceptibility of Pseudo cercospora herpotrichoides to cyproconazole increased following exposure to dicamba, bromoxynil, or ioxynil (Kataria and Gisi, 1990; Levesque and Rahe, 1992).

The influence of the postemergence herbicides clethodim, imazapic, lactofen, and 2,4-DB on boron and manganese absorption into peanut leaves was evaluated, and results suggested that while herbicides could affect accumulation of boron and manganese in leaf tissue, the adjuvant associated with these herbicides may have been the primary factor in influencing absorption (Jordan et al., 2006, 2009a).

11. Application variables that can affect interactions

A wide range of application variables can affect interactions of herbicides with other agrochemicals. Adjuvant selection, herbicide rate, commercial formulation, active ingredient, length of time between applications of components, spray volume, water quality, weed species, and environmental conditions can affect interactions of agrochemicals. For example, the negative effect of bentazon was reduced by including ammonium sulfate and other more efficacious adjuvants with clethodim and sethoxydim (Jordan, 1995; Jordan and York, 1989; Penner, 1989; Wanamarta and Penner, 1989; York et al., 1990). Applying a higher rate of the herbicide that may be adversely affected can compensate for interactions (Chernicky and Slife, 1986; Rhodes and Coble, 1984a, 1984b). Differential response to clethodim was noted when applied with different formulations of chlorothalonil (Jordan et al., 2003a). Increasing the interval between applications of components of the mixture can overcome negative interactions, especially herbicide-herbicide interactions (Green, 1989; Grichar and Boswell, 1987; Putnam and Ries, 1967). Applying graminicides in higher spray volumes can exacerbate the negative influence of herbicides and fungicides on weed control by graminicides (Buhler and Burnside, 1984; Jordan et al., 2003a; Kells and Wanamarta, 1987). Water quality, in particular presence of cations that can form complexes in the spray solution, can influence the propensity of herbicides to perform poorly in pesticide combinations (Buhler and Burnside, 1983a, 1983b; Hatzios and Penner, 1985; Sandberg et al., 1978; Stahlman and Phillips, 1979; Thelen et al., 1995; Whisenant and Bovey, 1993; Wills and McWhorter, 1985).

Environmental conditions that affect plant response to agrochemicals can influence the magnitude of interactions. Negative effects of interactions associated with efficacy of systemic herbicides, especially graminicides, are exacerbated when grasses are stressed and physiological processes that reduce absorption and translocation occur (Burke et al., 2004; Burke and Wilcut, 2003; Green, 1989; Wanamarta and Penner, 1989; Wanamarta et al., 1989).
12. Challenges of defining interactions and making recommendations

Major challenges in recommending practices associated with interactions of herbicides with other agrochemicals include the diversity of products available, the diversity of weeds present in the field that can vary in response to herbicides, differences in water quality within and across production regions, and adjuvant recommendations associated with herbicides versus other agrochemicals. Compounding these complex variables is the unpredictable response often observed due to environmental conditions. Additionally, new active ingredients are being marketed that have not been evaluated for possible interactions, and as patents expire, some of these active ingredients are formulated differently from the product receiving the initial registration. The extensive number of possible combinations, especially when multiple components are considered, is challenging from a research standpoint when considering the logistics of research trials needed to address possible interactions. Although attempts are made to establish research trials in a manner similar to practitioner operations, techniques associated with maintaining spray solutions and applying materials with small-plot equipment differ from commercial applications and adds to the challenges in research.

One reasonable criticism of the current approach to defining interactions, which is dictated by the number of combinations and the logistics of experimentation, is the lack of defining the impact of interactions on the larger context of the production system. For example, when a reduction in weed control by a fungicide occurs, how detrimental to peanut yield and economic value is this reduction when considering alternatives to prevent the interaction from occurring? Also, dose response curves are often used to define interactions of pesticides, and while these can be more informative than selection of a single rate of the components in the mixture, the number of treatment combinations required for this approach is often not feasible because of resource constraints.

13. Future research

A considerable knowledge base has been developed to define interactions of herbicides with other agrochemicals with respect to weed control in peanut. However, the effect of herbicides on performance of fungicides and insecticides is limited but no less important than defining impacts on herbicide efficacy. As new active ingredients and new formulations of active ingredients become available, additional research will be needed to define interactions among these agrochemicals. Although interactions of herbicide-herbicide combinations have been defined broadly and in some cases in detail, research elucidating the mechanism of reduced control associated with co-application of fungicides, insecticides, or plant growth regulator and micronutrients is limited (Duke et al., 2007). Finally, determining the impact of interactions in the overall production system would be beneficial.
<table>
<thead>
<tr>
<th>Pest</th>
<th>Latin binomial and authority</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Weeds</strong></td>
<td></td>
</tr>
<tr>
<td>Bermudagrass</td>
<td>Cynodon dactylon (L.) Pers.</td>
</tr>
<tr>
<td>Bristly starbur</td>
<td>Acanthospermum hispidum DC.</td>
</tr>
<tr>
<td>Broadleaf signalgrass</td>
<td>Urochloa platypyllla (Nash) R.D. Webster</td>
</tr>
<tr>
<td>Common cocklebur</td>
<td>Xanthium strumarium L.</td>
</tr>
<tr>
<td>Common lambsquarters</td>
<td>Chenopodium album L.</td>
</tr>
<tr>
<td>Common ragweed</td>
<td>Ambrosia artemisiifolia L.</td>
</tr>
<tr>
<td>Crabgrass spp.</td>
<td>Digitaria spp.</td>
</tr>
<tr>
<td>Crowfootgrass</td>
<td>Dactylctenium aegyptum (L.) Willdl.</td>
</tr>
<tr>
<td>Eclipta</td>
<td>Eclipta prostrata L.</td>
</tr>
<tr>
<td>Florida beggarweed</td>
<td>Desmodium tortuosum (Sw.) DC.</td>
</tr>
<tr>
<td>Florida pusley</td>
<td>Richardia scabra L.</td>
</tr>
<tr>
<td>Goosegrass</td>
<td>Eleusine indica (L.) Gaertn.</td>
</tr>
<tr>
<td>Hairy indigo</td>
<td>Indigofera hirsuta Harvey</td>
</tr>
<tr>
<td>Jimsonweed</td>
<td>Datura stramonium L.</td>
</tr>
<tr>
<td>Johnsongrass</td>
<td>Sorghum halepense (L.) Pers.</td>
</tr>
<tr>
<td>Morningglory spp.</td>
<td>Ipomoea spp.</td>
</tr>
<tr>
<td>Nutsedge spp.</td>
<td>Cyperus spp.</td>
</tr>
<tr>
<td>Palmer amaranth</td>
<td>Amaranthus palmeri S. Wats.</td>
</tr>
<tr>
<td>Pigweed spp.</td>
<td>Amaranthus spp.</td>
</tr>
<tr>
<td>Prickly sida</td>
<td>Sida spinosa L.</td>
</tr>
<tr>
<td>Sicklepod</td>
<td>Senega obtusiifolia (L.) H.S. Irwin &amp; Barneby</td>
</tr>
<tr>
<td>Spurge spp.</td>
<td>Chamaesyce spp.</td>
</tr>
<tr>
<td>Texas millet</td>
<td>Urochloa texana (Buckl.) R. Webster</td>
</tr>
<tr>
<td>Tropic croton</td>
<td>Croton glandulosus var. septentrionalis Muell.-Arg.</td>
</tr>
<tr>
<td><strong>Insects</strong></td>
<td></td>
</tr>
<tr>
<td>Beet armyworm</td>
<td>Spodoptera exigua Hübner</td>
</tr>
<tr>
<td>Corn earworm</td>
<td>Heliothis zea Boddie</td>
</tr>
<tr>
<td>Lesser cornstalk borer</td>
<td>Elasmopalpus lignosellus Zeller</td>
</tr>
</tbody>
</table>

www.intechopen.com
### Pest Latin binomial and authority

<table>
<thead>
<tr>
<th>Pest</th>
<th>Latin binomial and authority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern corn rootworm</td>
<td><em>Diabrotica undecimpunctata</em> Howardi</td>
</tr>
<tr>
<td>Thrips</td>
<td><em>Frankliniella</em> spp.</td>
</tr>
</tbody>
</table>

### Diseases
- Aspergillus crown rot: *Aspergillus niger*
- Botrytis: *Botrytis cinerea* Pers.
- *Cylindrocladium* black rot: *Cylindrocladium parasiticum* Crous, Wingfield, and Alfenas
- Early leaf spot: *Cercospora arachidicola* Hori
- Late leaf spot: *Cercosporidium personatum* Berk. & Curtis
- Pythium: *Pythium* spp.
- Rhizoctonia limb rot: *Rhizoctonia solani* Kuhn
- Sclerotinia blight: *Sclerotinia minor* Jagger
- Spotted wilt: *Tomato spotted wilt, caused by a Tospovirus*
- Stem rot: *Sclerotium rolfsii* Sacc.
- Web blotch: *Phoma arachidicola* Marasas, Pauer, and Boerema

### Plant parasitic nematodes
- Lesion nematode: *Pratylenchus brachyurus*
- Northern root knot: *Meloidogyne hapla*
- Peanut root knot: *Meloidogyne arenaria*
- Ring: *Criconemella ornata*
- Sting: *Belonolaimus longicaudatus*
- Two-spotted spider mite: *Tetranychus urticae* Koch

---

Table 1. Common and scientific names for major pests found in peanut in the United States.

---

<table>
<thead>
<tr>
<th>Active Ingredient</th>
<th>Herbicides</th>
<th>Insecticides</th>
<th>Fungicides</th>
<th>Fumigants</th>
<th>Plant growth regulators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acifluorfen</td>
<td></td>
<td>Acephate</td>
<td>Azoxyystrobin</td>
<td>Dichloropropene plus chloropicrin</td>
<td>Prohexadione calcium</td>
</tr>
<tr>
<td>Alachlor</td>
<td></td>
<td>Aldicarb</td>
<td></td>
<td>Basic copper sulfate</td>
<td></td>
</tr>
<tr>
<td>Bentazon</td>
<td>Bacillus thuringiensis</td>
<td></td>
<td></td>
<td>Metam sodium</td>
<td></td>
</tr>
<tr>
<td>Carfentrazone</td>
<td></td>
<td>Carbaryl</td>
<td>Chlorothalonil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clethodim</td>
<td></td>
<td>Chlorpyrifos</td>
<td>Dodine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diclosulam</td>
<td></td>
<td>Disulfoton</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimethenamid-P</td>
<td></td>
<td>Esfenvalerate</td>
<td></td>
<td>1,3 dichloropropene</td>
<td></td>
</tr>
<tr>
<td>Ethafluralin</td>
<td></td>
<td>Fenpropathrin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flumioxazin</td>
<td></td>
<td>Gamma-cyhalothrin</td>
<td></td>
<td>Mancozeb</td>
<td></td>
</tr>
<tr>
<td>Glyphosate</td>
<td></td>
<td>Indoxacarb</td>
<td></td>
<td>Mancozeb and copper hydroxide</td>
<td></td>
</tr>
<tr>
<td>Imazapic</td>
<td></td>
<td>Lambda-cyhalothrin</td>
<td></td>
<td>Mefenoxam</td>
<td></td>
</tr>
<tr>
<td>Imazethapyr</td>
<td></td>
<td>Malathion</td>
<td></td>
<td>Metconazole</td>
<td></td>
</tr>
<tr>
<td>Lactofen</td>
<td></td>
<td>Methomyl</td>
<td></td>
<td>Pentachloronitrobenezene (PCNB)</td>
<td></td>
</tr>
<tr>
<td>Metolachlor</td>
<td></td>
<td>Phorate</td>
<td></td>
<td>Propiconazole</td>
<td></td>
</tr>
<tr>
<td>Paraquat</td>
<td></td>
<td>Propargite</td>
<td></td>
<td>Prothioconazole</td>
<td></td>
</tr>
<tr>
<td>Pendimethalin</td>
<td></td>
<td>Spinosad</td>
<td></td>
<td>Pyraclostrobin</td>
<td></td>
</tr>
<tr>
<td>Sethoxydim</td>
<td></td>
<td></td>
<td></td>
<td>Sulfur</td>
<td></td>
</tr>
<tr>
<td>S-metolachlor</td>
<td></td>
<td></td>
<td></td>
<td>Tebuconazole</td>
<td></td>
</tr>
<tr>
<td>Sulfentrazone</td>
<td></td>
<td></td>
<td></td>
<td>Thiophanate methyl</td>
<td></td>
</tr>
<tr>
<td>2,4-DB</td>
<td></td>
<td></td>
<td></td>
<td>Trifloxystrobin</td>
<td></td>
</tr>
</tbody>
</table>


Table 2. Pesticide active ingredients registered for use in peanut in the United States during 2010. 

www.intechopen.com
Table 3. Biotic and abiotic stresses and approximate timing of management that can occur in peanut during the growing season in the United States.

<table>
<thead>
<tr>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Weeds</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dicotyledonous</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monocotyledonous</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Insects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beet armyworm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn earworm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lesser cornstalk borer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Southern corn rootworm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tobacco thrips</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Diseases</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspergillus crown rot</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Botrytis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cylindrocladium black rot</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cercospora spp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pythium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhizoctonia limb rot</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sclerotinia blight</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spotted wilt</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stem rot</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Web blotch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Plant parasitic nematodes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two-spotted spider mite</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Nutrient deficiency</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boron</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manganese</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Peanut vine management</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prohexadione calcium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

14. References


The content selected in Herbicides, Theory and Applications is intended to provide researchers, producers and consumers of herbicides an overview of the latest scientific achievements. Although we are dealing with many diverse and different topics, we have tried to compile this “raw material” into three major sections in search of clarity and order - Weed Control and Crop Management, Analytical Techniques of Herbicide Detection and Herbicide Toxicity and Further Applications. The editors hope that this book will continue to meet the expectations and needs of all interested in the methodology of use of herbicides, weed control as well as problems related to its use, abuse and misuse.

How to reference

In order to correctly reference this scholarly work, feel free to copy and paste the following:
