metalworking formulations. Other informative tests would include oxidation and thermal stability of formulated oils and evaluation of emulsion and foaming characteristics when water is present. Several specific, simulated in-use performance tests could be run such as high speed and high torque gear lubricant tests and transmission fluid tests.

Lard oil-based sulfurized products, including those sulfurized alone without ester, historically have been shown to have adequate and often outstanding overall performance as lubricant additives, depending on application. Many of the products from lower grade animal greases generally share these advantages; their main disadvantages are poor low temperature handling properties and semisolid appearance, sometimes including the presence of titered fat or stearines. In most cases these disadvantages do not outweigh price advantages. In other cases, higher load carrying and/or lower friction provided by some sulfurized vegetable oil products may translate into specialized applications. With customers becoming increasingly selective about particular performance and physical properties, the increased use of vegetable oils in sulfurization is anticipated, especially if the price differential between vegetable oil- and animal-based raw materials narrows.

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Uses of Soybean Oil in the Application of Herbicides

GEORGE KAPUSTA, Department of Plant and Soil Science, Southern Illinois University, Carbondale, IL 62901

ABSTRACT

Field studies were conducted in 1982 and 1983 at Southern Illinois University to evaluate soybean oil as a carrier for preemergence and postemergence herbicides and as an enhancing agent for postemergence herbicides. Preemergence and postemergence herbicides applied with rotary nozzles in a soybean oil carrier volume as low as 5 L/ha afforded weed control equal to that achieved when the herbicides were applied in 187 L/ha water with flat fan nozzles. Soybean oil as an enhancing agent for four postemergence soybean herbicides was equal to petroleum crop oil concentrate with three of the herbicides but distinctly less effective with the fourth herbicide.

INTRODUCTION

Farmers have used oils for many years directly for the control of weeds and insects and as additives to herbicides to increase their efficacy. Oils also have been used as solvents in the manufacture of pesticides (1). The development of selective herbicides and insecticides relegated oils for the direct control of pests to minor status. Petroleum oil fractions have been added to 2,4-D and 2,4,5-T for the control of woody species in rangeland (2) but have not been used with 2,4-D for weed control in cereal grains because of potential injury to the crop. Several decades ago it was found that a phytobland oil added to atrazine improved the control of many weeds in corn (3). Later, the use of emulsifiable crop origin oils (oil extracted from crops such as soybeans, cotton, flax, etc.) at 2.3 L/ha was found to be as effective as 9.3 L/ha of petroleum oil in enhancing weed control in corn with atrazine and cyanazine (4-6).

More recently, the development of selective postemergence herbicides for soybeans, cotton and other important economic crops has increased the application of these herbicides on millions of hectares each year. The nine major farm crops are grown on approximately 182 million hectares in the U.S. and on 800 million hectares in the world annually (7). A very high percentage of the cropland in the U.S. is treated with one or more pesticides, sometimes with multiple applications.

PESTICIDE APPLICATION

Pesticides must be diluted in a carrier to be applied uniformly. The carrier to date has been water almost exclusively, applied with hydraulic sprayers that have not changed in 50 years. Volumes as high as 200 L/ha are used routinely, resulting in very inefficient spray operations because of the need for frequent refilling of the spray tank.

Recently, pesticide application with rotary atomizers was commercialized. This type of spraying depends on a spinning cone that discharges the spray solution from the rim of the cone as a series of very uniform droplets. The major advantage of rotary nozzles is that they can apply pesticides very uniformly in carrier volumes as low as 2 to 3 L/ha. This makes practical the use of crop origin oils as a carrier for pesticides, because the cost would be only several dollars per hectare.

POTENTIAL MARKET FOR CROP ORIGIN OILS

The use of postemergence herbicides on crops such as soybeans and cotton is increasing dramatically in the U.S. and many other countries. It is estimated that approximately 25% of the soybean acreage in Illinois is sprayed with postemergence herbicides annually for a total of one million hectares. Almost all of these applications include the addition of an enhancing agent such as a phytobland petroleum oil concentrate at about 2.5 L/ha.

The adoption of crop origin oils such as soybean oil as carriers and enhancing agents in the application of pesticides could create a substantial new market for oilseed crops.

The objective of this research was to evaluate soybean oil as a carrier and an enhancing agent for the application of soil-applied and postemergence herbicides.

EXPERIMENTAL PROCEDURES

Field studies were conducted in 1982 at the Agronomy Research Center at Carbondale and in 1983 on a farm location at Murphysboro, Illinois. All studies were arranged as randomized complete block designs with three replications. Individual plots consisted of five rows per plot, 15m long with 76cm row spacing in the 1982 studies, and four rows per plot, 9m long with 76cm row spacing in the 1983 study. "Williams 79" soybeans were used for all studies. The soil type at the Agronomy Research Center was a Weir silt loam with 1.5 percent organic matter, and at Murphysboro an Alvin sandy loam with 1.5 percent organic matter.

All flat fan applications were made with a hand-held CO_2 sprayer in 187 L/ha water at 207 kPa using 8002 tips. The Micromax rotary nozzles used were operated at 3500 rpm for the application of all postemergence herbicides at Carbondale. Preemergence herbicide applications in water and soybean oil (SBO) were made at 2000 and 3500 rpm, respectively. Rotary nozzles were spaced 99cm apart to obtain a full overlap pattern. The soybean oil used in 1982 was Natur'l Oil from Stoller Chemical Company, Houston, Texas, a 93:7 blend of once-refined soybean oil plus emulsifier. An 85:15 blend of fully-refined soybean oil plus emulsifiers obtained from the American Soybean Association was used for the enhancement study in 1983. The petroleum crop oil concentrate (PCOC) used in 1983 consisted of an 83:17 blend of phytobland petroleum oil plus emulsifiers.

Weeds were 3 to 10cm in height in 1982 at application of the postemergence herbicides. Johnsongrass was 50 to 75cm in height when the herbicides were applied in 1983. Bentazon at 0.84 kg/ha was applied in 5, 7 and 9 L/ha SBO and in 9, 19 and 37 L/ha water with rotary nozzles and in 187 L/ha water with flat fan nozzles in the postemergence study in 1982. All bentazon applied with rotary nozzles in water included PCOC at 10% v/v. Bentazon applied with flat fan nozzles included PCOC at 2.3 L/ha. Alachlor at 2.24 kg/ha and metribuzin at 0.42 kg/ha, alone and in a tank mix combination, were applied preemergence with rotary nozzles in 5 and 9 L/ha SBO (7.24 and 9.24 L/ha total volume of SBO plus herbicide, respectively) and in 7 and 9 L/ha total carrier (SBO plus herbicide). The same herbicide rates also were applied with rotary nozzles in 9 and 19 L/ha water and with flat fan nozzles in 187 L/ha water. Metribuzin had to be predissolved in a 5:1 herbicide: water slurry prior to adding it to the SBO, because it was not compatible when added directly to the SBO.

Weed control by individual species was evaluated visually on June 20, 1982, in the postemergence and preemergence studies and on August 10, 1983, in the postemergence johnsongrass study. Later observations indicated no difference in control from the initial rating.

All data was subjected to analysis of variance and means separated using Duncans Multiple Range Test.

RESULTS AND DISCUSSION

Soybean Oil as a Postemergence Soybean Herbicide Carrier

Bentazon was not compatible in soybean oil without emulsifiers, thus Natur'l Oil was used as the carrier. Emulsifiers and agitation are required for bentazon to suspend satisfactorily in soybean oil.

Weed control obtained with the soybean oil carrier treatments was equal to that obtained with all water carrier treatments applied with rotary and flat fan nozzles (Table I). Differences in weed control were not significant between the several application treatments. All treatments provided good to excellent control of common ragweed, common lambsquarters, Pennsylvania smartweed, jimsonweed and velvetleaf. The control of ivyleaf morningglory was poor to fair regardless of the carrier or nozzle used.

Applications with the rotary nozzles using soybean oil carrier volume as low as 5 L/ha afforded weed control equal to that obtained with rotary and flat fan applications using higher volumes of soybean oil or water (Table I). The control of the six weed species in this study was equal whether bentazon was applied with rotary or flat fan nozzles.

Soybean yields ranged from 2196 kg/ha in the nontreated check to a high of 2509 kg/ha (Table I). Although these differences were not significant, the practical importance of weed control manifests itself in other ways. Harvesting is more efficient, the grain is of higher quality for both market and seed purposes, and weed infestations in future years are reduced because production of weed seed has been decreased.

Soybean Oil as a Preemergence Soybean Herbicide Carrier

Metribuzin was not soluble in the soybean oil used. Predissolving the metribuzin in water in a 5:1 ratio allowed it to suspend satisfactorily in SBO to achieve uniform application. Pesticide formulations other than emulsifiable concentrates may have to be formulated specifically to assure adequate suspension in soybean oil to achieve uniform application.

Rotary nozzle applications of alachlor, metribuzin and alachlor plus metribuzin in soybean oil provided equal control of most weeds compared to that obtained with rotary and flat fan nozzles using water as the herbicide carrier (Table II). Although the control of common lambsquarters was significantly less with several of the treatments, the differences would not be of practical importance since the difference between the lowest and highest control was only 3%. The significance of the lower control of jimsonweed obtained with alachlor applied with rotary nozzles in 9 L/ha of SBO is not readily apparent because the same rate applied in 5 L/ha afforded excellent control.

There were no significant differences in weed control between herbicides applied in soybean oil carrier volumes as low as 5 L/ha compared to flat fan applications in 187 L/ha of water (Table II). Application methods did not influence weed control with any herbicide or herbicide combination.

Soybean yields ranged from 1537 kg/ha in the nontreated plots to a high of 2258 kg/ha in treated plots. These differences were not significant and may be related to substantial variability in crop injury caused by herbicides. The first replication exhibited no injury, and the second and third replications each averaged 30% crop injury.

Evaluation of SBO vs PCOC with Postemergence Herbicides for Johnsongrass Control

Rhizome johnsongrass control with sethoxydim, fluazifop-butyl, HOE 581 and DPX-Y6202 ranged from poor (less than 50%) to good (greater than 85%) in 1983 (Table III), in contrast to mostly excellent control achieved with the same herbicides in previous years. Translocation of the herbicides into the rhizomes apparently was incomplete because of drought stress.

TABLE I

Evaluation of Soybean Oil as a Carrier for Postemergence Soybean Herbicides Applied with Rotary Nozzles, Carbondale, 1982

Treatment	Rate	Application details			% Control, rated June 20						Soybean yield
		Nozzle type[a]	Carrier volume	Carrier type	Colq[b]	Corw	Pesw	Jiwe	Vele	Ilmg	
	(Kg/ha)		(L/ha)								(Kg/ha)
Nontreated					0	0	0	0	0	0	2196
Bentazon	0.84	RN	5	SBO[c]	97	92	95	93	98	38	2258
Bentazon	0.84	RN	7	SBO	97	92	95	91	91	26	2196
Bentazon	0.84	RN	9	SBO	97	94	97	89	98	40	2321
Bentazon	0.84	RN	9	Water	98	97	97	98	98	41	2384
Bentazon	0.84	RN	19	Water	98	97	97	98	98	62	2509
Bentazon	0.84	RN	37	Water	98	98	98	98	98	48	2321
Bentazon	0.84	FF	187	Water	98	98	98	98	98	52	2448

[a]RN = Micromax rotary nozzle at 3500 rpm; FF = 8002 flat fan nozzles.

[b]Colq = common lambsquarters; Corw = common ragweed; Pesw = Pa. smartweed; Jiwe = jimsonweed; Vele = velvetleaf; Ilmg = ivyleaf morningglory.

[c]SBO = Stoller Chemical Co. Natur'l. Oil (93% once refined soybean oil plus 7% emulsifier).

TABLE II

Evaluation of Soybean Oil as a Carrier for Preemergence Soybean Herbicides Applied with Rotary Nozzles, Carbondale, IL, 1982

Treatment	Rate	Application details				% Control, rated June 20						Soybean yield[c]
		Nozzle type[a]	Carrier type[b]	Carrier total	Volume oil	Gift[d]	Yens	Colq	Corw	Jiwe	Ilmg	
	(Kg/ha)			(L/ha)	(L/ha)							(Kg/ha)
Nontreated						0	0	0	0	0	0	1537
Alachlor	2.24	RN	SBO	7		98	97	97 ab	96	96 ab	68	2196
Alachlor	2.24	RN	SBO	9		98	97	98 a	97	97 ab	84	2133
Metribuzin	0.42	RN	SBO	7		96	94	98 a	96	97 ab	80	2007
Metribuzin	0.42	RN	SBO	9		90	98	98 a	94	94 ab	85	2133
Alachlor + metribuzin	2.24 +0.42	RN	SBO	7		98	98	98 a	98	97 ab	76	1819
Alachlor + metribuzin	2.24 +0.42	RN	SBO	9		98	98	98 a	98	98 a	67	2133
Alachlor	2.24	RN	SBO		5	98	97	97 ab	96	94 ab	70	2133
Alachlor	2.24	RN	SBO		9	98	91	98 a	89	72 c	83	2070
Metribuzin	0.42	RN	SBO		5	96	94	98 a	97	96 ab	87	2196
Metribuzin	0.42	RN	SBO		9	95	94	98 a	98	97 ab	82	2258
Alachlor + metribuzin	2.24 +0.42	RN	SBO		5	98	78	96 bc	96	96 ab	72	2196
Alachlor + metribuzin	2.24 +0.42	RN	SBO		9	98	90	98 a	98	97 ab	67	2007
Alachlor	2.24	RN	Water	9		97	96	98 a	98	97 ab	79	2133
Alachlor	2.24	RN	Water	19		98	93	98 a	98	96 ab	83	2133
Metribuzin	0.42	RN	Water	9		97	94	97 ab	97	96 ab	69	2007
Metribuzin	0.42	RN	Water	19		92	92	98 a	98	91 ab	71	2007
Alachlor + metribuzin	2.24 +0.42	RN	Water	9		98	98	98 a	98	98 a	86	1631
Alachlor + metribuzin	2.24 +0.42	RN	Water	19		98	93	98 a	98	98 a	62	2258
Alachlor	2.24	FF	Water	187		98	96	95 c	96	89 ab	73	2070
Metribuzin	0.42	FF	Water	187		98	89	98 a	98	98 a	76	1945
Alachlor + metribuzin	2.24 +0.42	FF	Water	187		98	98	98 a	98	98 a	88	1756

[a]RN = Micromax rotary nozzles at 2000 and 3500 rpm with water and soybean oil, respectively.

[b]SBO = Stoller Chemical Co. Natur'l Oil (93% once refined soybean oil plus 7% emulsifier).

[c]Means within columns followed by one or more like letters are not different at the 5% level according to Duncan's Multiple Range Test (values within a column not followed by letters are not significantly different).

[d]Gift = giant foxtail; Yens = yellow nutsedge; Colq = common lambsquarters; Corw = common ragweed; Jiwe = jimsonweed; Ilmg = ivyleaf morningglory.

PCOC consistently increased the control of johnsongrass when added to the four herbicides, compared to applying them without any additive. However, the increases were significant only with DPX-Y6202, which afforded the most complete control. SOC was equal to PCOC in enhancing the control of johnsongrass with sethoxydim, fluazifop-butyl and HOE 581, but distinctly less effective than PCOC with DPX-Y6202. Results from other studies substantiate these observations. Additives such as oils or surfactants do not consistently increase the efficacy of herbicides. Enhancement usually is of a lower magnitude when environmental or other conditions preclude optimum expression of the herbicide, as occurred in this study.

Future of Soybean Oil in the Application of Herbicides

Reducing the carrier volume to very low amounts was the major benefit observed from the use of SBO with rotary nozzles. This greatly increases the efficiency of spray operations because the frequent refilling associated with current application methods is eliminated. This also will decrease the cost of spraying since a greater area can be sprayed each day and there is little need for trucks hauling carrier to the field. The initial greater investment associated with rotary nozzles compared to conventional sprayers would be recovered in several years.

The most immediate promise for the widespread adoption of SBO is as an additive to postemergence herbicides applied with conventional sprayers, because investment in new equipment is not needed. Results from the johnsongrass study (Table III) and more recent research indicate that it is equal to PCOC in enhancing the activity of essentially all postemergence herbicides.

Growers using SBO as a carrier will need to clean their equipment frequently because a film of oil deposits on it during spraying. Compatibility between the SBO and each herbicide will need to be determined in advance to preclude problems in the field. In addition, applicators may need to wear protective clothing more routinely because the oil may increase absorption of the herbicide through the skin.

Studies are continuing at Southern Illinois University and at other universities to further evaluate the potential of SBO as a carrier and additive for herbicides.

TABLE III

Evaluation of Soybean Oil Concentrate vs. Petroleum Oil Concentrate as Enhancing Agents with Postemergence Herbicides for Johnsongrass Control in Soybeans, Murphysboro, 1983

Herbicide	Rate	% Control[c], Aug. 10 Additive, 2.3 L/ha		
		None	PCOC[a]	SOC[b]
	(G/ha)			
Nontreated				
Sethoxydim	84	8 d	18 d	28 cd
Sethoxydim	140	18 d	37 cd	37 cd
Sethoxydim	210	33 cd	45 c	47 c
Fluazifop-butyl	84	35 cd	30 cd	37 cd
Fluazifop-butyl	140	62 bc	80 ab	55 bc
Fluazifop-butyl	210	75 b	83 ab	77 b
HOE 581	70	37 cd	52 c	32 cd
HOE 581	105	48 c	57 bc	55 bc
HOE 581	140	62 bc	67 bc	52 c
HOE 581	175	80 ab	–	–
DPX-Y6202	18	8 d	40 cd	5 d
DPX-Y6202	35	38 cd	73 b	27 cd
DPX-Y6202	53	67 bc	90 a	40 cd
DPX-Y6202	70	77 b	–	–

[a]Petroleum oil 83% plus emulsifiers 17%.
[b] Fully refined soybean oil 85% plus emulsifiers 15%.
[c]Values within and between columns followed by one or more like letters are not different at the 5% level according to Duncan's Multiple Range Test.

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Trends in Industrial Use of Vegetable Oils in Coatings

RICHARD W. FULMER, Research Center, Cargill, Inc., P.O. Box 9300, Minneapolis, MN 55440

ABSTRACT

Alkyd resins continue to be a major factor in coatings. Increased oil consumption in alkyd manufacture is not expected to be significant. Projections indicate a modest growth in total coatings usage at 2-3% per year. The industry is facing diverse coating performance demands that will bring unusual, more costly ingredients into use, probably at the expense of traditional oil-based alkyd resins. Offsetting this oil usage decline, perhaps, will be the continuing cost advantage of the relatively low-priced vegetable oils and the general versatility of alkyd resins. Increased use of oil-based resins is expected in emulsion (latex) paint modifiers to improve adhesion and early water resistance. The coatings industry, at least in maintenance and industrial coatings, is adopting a cost/sq ft/year economic evaluation, facotoring in the useful life of the coating.

INTRODUCTION

Very few indicators, if any, point to significant change in the overall consumption of vegetable oils in the surface coatings industry in the U.S. during the next five years. Projections indicate a modest, continued physical growth of 2-3% per year in coatings consumption, more particularly in resin solids. Fluctuations are anticipated in total coatings dollar value due to business cycles, inflation rates and variations in raw material supply costs.

The impact of changes in coatings consumption or technology on vegetable oil usage will be difficult to discern. Industrial usage of vegetable oils is small compared with total food uses. Estimates vary, but generally agree, that only 5-7% of total vegetable oil consumption occurs in nonfood uses. Therefore, it is difficult in an established industry such as surface coating resins to discuss changes that would demonstrate a significant impact on total oil industry volume.

Nevertheless, this paper will examine the paint industry in the U.S. with comments toward expected technical developments in film-forming resin compositions.

DISCUSSION

Any useful perspective requires some understanding of the paint industry and its raw materials.

From 1970 to 1982, U.S. paint production increased from 830 million gallons to 930 million gallons, with a peak year of 1065 million gallons in 1979 just prior to the economic downturn in automobiles, housing and durable goods. During the same period, the value of U.S. paint production rose from \$2.6 billion to \$8.3 billion.

Value per gallon steadily rose during the 12-yr period