

Research Paper

Sesame Tolerance to Directed Postemergence Herbicides ~~Applied Postemergence-Directed~~

Abstract. Field studies were conducted during the 2006 and 2007 growing seasons under weed-free conditions in south Texas and the Texas High Plains to determine sesame tolerance to directed post-emergence herbicides ~~applied postemergence directed~~ to the lower 5 and 15 cm of the sesame main stem. Sesame injury was greatest when herbicides were applied to 15 cm of the main stem compared to herbicide applications made to 5 cm of the main stem height. Glyphosate at 0.84 kg ae/ha and pyriithiobac at 0.07 kg ai/ha resulted in the greatest sesame stunting (28 to 90%) when applied up to 15 cm main stem height. When glyphosate was applied up to 5 cm main stem height, sesame injury was 20% or less. Glyphosate applied up to the 15 cm stem height and pyriithiobac applied 5 and 15 cm stem height consistently reduced sesame yield (how much give %) when compared with the non-~~treated control~~ treated control. Glufosinate-ammonium and the premix of linuron plus diuron applied up to the 5 cm stem height caused the least sesame stunting and resulted in no reduction in sesame yield when compared with the non-treated control.

Keywords: Injury, *Sesamum indicum*, yield.

1. Introduction.

Sesame (*Sesamum indicum* L.) is one of the oldest crops known to humans. There are archeological remnants of sesame dating to 5500 BC in the Harappa Valley in the Indian subcontinent [1]. Assyrian tablets from 4300 BC describe how before the gods battled to restore order to the universe, they ate bread and drank sesame wine [2].

Sesame was a major oilseed in the ancient world because of its ease of extraction, great stability, and drought resistance. In India today, almost as in olden days, a farmer can take ~~their his~~ crop to ~~an expeller which consist~~ an expeller which consists of grinding mortar and pestle stones driven by a bullock. They can place the oil in a vessel, take it back to their home and have cooking oil for a year without the oil going rancid (S.S. Rajan, personal communication).

Sesame was introduced to the US from Africa and was called beni/benne/benni [3]. Betts [3] quotes letters from Thomas Jefferson that document his trials with sesame between 1808 and 1824. Jefferson stated that sesame “...is among the most valuable acquisitions our country has ever made. ... I do not believe before that there existed so perfect a substitute for olive oil.” He talks about the rule of thumb that still exists today - that sesame will grow well where cotton grows well.

Sesame was produced in Texas on a limited scale during the 1950's and early 1960's, first in northeast Texas and later shifting to the High Plains, where consistent yield increases resulted from irrigation and more favorable climate conditions [4]. The sesame was cut with a binder, hand-shocked, and manually fed into a combine when dry. Due to a change in guest worker laws in the mid 1960's, the hand labor from Mexico became unavailable and the sesame crop disappeared [5]. Sesame returned to Texas in 1987 with

1 varieties that did not require binding and shocking. Sesame could be swathed into a
2 windrow, allowed to dry, and removed from the field with a pick-up attachment on a
3 combine. Since that time new varieties have been developed that can be left standing in
4 the field to dry down and then combined directly. Also, sesame has spread to other states
5 including Oklahoma and Kansas [5].

6 One of the more difficult problems in planting sesame is that the seeds are small and
7 need to be placed precisely in the soil [6]. Seeds cannot be too deep that the cotyledons
8 never reach the surface, and yet they cannot be too shallow that topsoil moisture around
9 the seed is lost. Once the cotyledons emerge they are small compared to other crops and
10 seedlings do not grow fast. This slow development is compounded by the nature of the
11 drought resistance of sesame in that it will partition a large portion of photosynthetic
12 resources to create more root mass to penetrate the soil as quickly as possible. In the first
13 30 days after planting, plants reach about 28 cm in height and will double to 60 cm in the
14 next 11 days, triple to 90 cm in the following 8 days, and quadruple to 120 cm in the
15 following 9 days. At this maturity point the sesame will begin to canopy. Depending on
16 row spacing and phenotype, mechanization of sesame requires good weed control for 50
17 to 60 days after planting [6].

18 | The presence of weeds can negatively influence sesame yields. Kropff and Spitters [7]
19 reported that the major factor influencing sesame yield loss in a competitive situation
20 between the crop and weed is the ratio between the relative leaf area of the weed and the
21 crop at the time of canopy closure. The effects of weeds on sesame establishment and
22 growth have been well-documented. Balyan [8], Gurnah [9], Singh et al. [10], and
23 Upadhyay [11] reported weed-induced reductions of sesame yield up to 100% and a need

for a critical weed-free period up to 50 day after planting. Under weedy conditions, Eagleton et al. [12] recorded a weed biomass six times that of sesame 48 days after planting and Bennett [13] reported a weed biomass 1.3 fold that of sesame 42 days after planting.

Mechanically harvested non-dehiscent varieties present another problem that is not present in manual harvest which comprises 99% of all sesame harvested in the world [5].

If there are weeds in manual harvest, only the sesame plants are cut and placed in shocks.

However, in mechanical harvest, sesame and weeds are cut together. In Venezuela, a binder cuts the sesame and weeds together while they are still green. This is not a big problem because the weeds dry down at the same time as the sesame. However, dense

population of weeds may delay combining because the leaves of the weeds may envelop

plants and trap moisture or thicker stem weeds such as pigweed (*Amaranthus* spp.) will

take longer to dry down. In direct combining, weeds can be a big problem because they

are normally green and add moisture to the combine bin. There are many instances

where the sesame seeds are dry and weed seeds are not. Thick stems can add moisture,

but the major problem is with weed seeds. Since it is logistically difficult to scalp off the

weed seeds at harvest, moisture from the weed seed will transfer to sesame seeds.

Sesame is 50% oil and needs to be harvested at 6% moisture or below in order to be

handled in lots of 25 tons in trucks and in 2,000 ton silos. High moisture under these

conditions may lead to heating and ruining of the seed. A second concern is that

mechanically harvested sesame moves through a series of augers from the combine

screen, to the combine bin, to the truck, to the silo, to the cleaning equipment, and within

the cleaning process. Moist sesame seeds may be damaged by this movement forming

free fatty acids which leads to spoiling [5].

1 The size of sesame seed is similar to the size of many weed seeds [14,15]. In the
2 production of oil from sesame, weed seeds within the sesame samples are not as critical
3 unless they are toxic. However, a large percentage of sesame is used in edible markets
4 that require 99.99% purity. There are weed seeds such as johnsongrass [*Sorghum*
5 *halepense* (L.) Pers] that would seemingly be easy to remove because of their size and
6 shape, and yet the johnsongrass seed go through the round holes end first and are difficult
7 to separate in gravity tables because they have a similar specific gravity to sesame [14].
8 In decortication of the seed for bakery products and tahini, the seed from lanceleaf sage
9 (*Salvia reflexa* Hornem.) causes a unique problem. When the lanceleaf sage seed is
10 hydrated, the seed surface forms a gelatinous substance that will cause adjacent sesame
11 seeds to stick; therefore, forming balls. Kochia [*Kochia scoparia* (L.) Schrad] and grass
12 weeds produce seeds that are difficult to remove from sesame. Any weed seed that is in a
13 sesame sample in a large percentage is difficult to clean out, no matter the size and
14 specific gravity, without having to slow down the processing or reprocessing. In Japan,
15 purity needs to be 100% since processors have to pay claims to customers that find
16 anything other than pure sesame seeds [5].

17 Sesame is mainly grown in countries where abundant and inexpensive labor is available
18 [16]. However, the trend in agriculture around the world is towards mechanization.
19 Sesame has disappeared in Japan and parts of Mexico as the sesame growing areas
20 mechanized. In Korea, sesame hectares have continually decreased since 1987 as the labor
21 migrates to the cities (C. Kang, personal communication). With weak seedling vigor,
22 limited competitive ability, and a lack of cheap labor, the use of pre-emergence (PRE) or

1 post-emergence (POST) herbicides ~~is~~ are essential for commercial mechanized sesame
2 production.

3 All POST herbicides which control broadleaf weeds in sesame have caused some
4 sesame injury or yield reduction [17,18,19]. For broadleaf weed problems in sesame, the
5 use of soil-applied herbicides still appears to be the only option [17,20]. However, since
6 sesame hectares are increasing in portions of the southern United States and since no POST
7 broadleaf herbicides are presently cleared for use on sesame or have shown sesame
8 tolerance [17,19], the objective of these studies was to identify herbicides that could be
9 used as directed post-emergence ~~directed~~ (DPEPDIR) to control broadleaf weeds and not
10 injure sesame.

11 2.0 Materials and Methods

12 2.1 Research sites. Field studies were conducted during the 2006 and 2007 growing
13 seasons near Uvalde in south Texas and near Lorenzo in the Texas High Plains to
14 evaluate sesame response to herbicides applied DPEPDIR. Fields were selected that had
15 low weed populations since weed efficacy of each herbicide is known; however, nothing
16 is known about sesame response to herbicides applied DPEPDIR. Soil type at Uvalde
17 was a Winterhaven silty clay loam (fine-silty, carbonatic, hyperthermic Fluventic
18 Ustochrepts) with less than 1.0% organic matter and pH 7.8. Soil type at Lorenzo was a
19 Amarillo sandy clay loam (fine-loamy, mixed, thermic Aridic Paleustalf) with 0.8%
20 organic matter and pH 7.8.

21 2.2 Plot design. A randomized complete-block experimental design was used and
22 treatments were replicated three times. Treatments consisted of a factorial arrangement
23 of fifteen herbicides applied at two different DPEPDIR spray heights. A non-treated

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control was included for comparison. Plot size was five rows (76 cm apart) by 9.1 M~~not~~
clear give length and width of plot. in south Texas and four rows (101 cm apart) by 7.3
m. in the Texas High Plains. Only the two middle rows were sprayed and the other rows
were untreated and served as buffers.

2.3 Herbicides and spraying information. Herbicides included carfentrazone-ethyl
(Aim®, FMC, 1735 Market Street, Philadelphia, PA 19103) at 0.02 kg ai/ha, glufosinate-
ammonium (Ignite 280®, Bayer Crop Science, 2 T. W. Alexander Drive, Research
Triangle Park, NC 27709) at 0.58 kg ai/ha, glyphosate (Roundup Weathermax®, a
potassium salt of glyphosate plus surfactant, Monsanto Company, 800 North Lindbergh
Boulevard, St. Louis, MO 63167 or Durango®, a potassium salt of glyphosate plus
surfactant, Dow AgroSciences, LLC, Indianapolis, IN 46268) at 0.84 kg ae/ha, lactofen
(Cobra®, Valent USA Corporation, P. O. Box 8025, Walnut Creek, CA 94596-8025) at
0.22 kg ai/ha, linuron (Linex®, DuPont Crop Protection, Laurel Run Building, Chestnut
Run Plaza, Wilmington, DE 19898) at 1.12 kg ai/ha, paraquat (Gramoxone Max®,
Syngenta Crop Protection, Inc., P. O. Box 18300, Greensboro, NC 27419) at 0.28 kg
ai/ha, propazine (Milo-Pro®, Albaugh, Inc., Ankeny, IA 50021) at 1.12 kg ai/ha,
pyraflufen-ethyl (ET®, Nichino America, Inc., 4550 New Linden Hill Road, Wilmington,
DE 19808) at 0.002 kg ai/ha, pyriithobac (Staple®, E. I. DuPont de Nemours,
Wilmington, DE 19898) at 0.07 kg ai/ha, trifloxysulfuron-sodium (Envoke®, Syngenta
Crop Protection, Inc., P. O. Box 18300, Greensboro, NC 27419) at 0.008 kg ai/ha,
trifloxysulfuron-sodium at 0.008 kg/ha plus prometryn (Suprend®, Syngenta Crop
Protection, Inc., P. O. Box 18300, Greensboro, NC 27419) at 1.12 kg ai/ha, linuron at
0.56 kg ai/ha plus diuron at 0.56 kg ai/ha (LaybyPro, Tessengerlo Kerley, Inc., 2255 N.

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44th St., Suite 300, Phoenix, AZ 85008), glyphosate plus prometryn (Caparol®, Syngenta Crop Protection, Inc., P. O. Box 18300, Greensboro, NC 27419) at 0.84 kg/ha plus 1.12 kg ai/ha, and glyphosate plus diuron (Direx®, DuPont Crop Protection, Laurel Run Building, Chestnut Run Plaza, Wilmington, DE 19898) at 0.84 kg ai/ha plus 1.12 kg ai/ha. Spray heights were up to 5 cm and 15 cm up the sesame main stem. All PDIR applications, with the exception of glufosinate-ammonium, included a crop oil concentrate (Agri-Dex®, a blend of 83% paraffin-based petroleum oil and 17% surfactant, Helena Chemical Company, Suite 500, 6075 Poplar Avenue, Memphis, TN 38137) at 1.0% v/v or a nonionic surfactant (X-77®, 90% nonionic surfactant, Loveland Industries, P.O. Box 1289, Greeley, CO 80632) at 0.25% v/v.

At Uvalde, herbicides were applied in water using a CO₂ pressurized backpack sprayer calibrated to deliver 190 L/ha at 180 kPa. Spray tips were two Teejet Tee jet 8004E (Teejet Spraying Systems Co., P.O. Box 7900, Wheaton, IL 60188) nozzles per row adjusted as to spray a ~~DPEPDIR~~ spray band on sesame stem and 15 to 25 cm band on the soil to simulate spray of a ~~DPEPDIR~~ spray applicator. At the Lorenzo location, a tractor-mounted compressed-air Red Ball sprayer with Teejet Tee jet 8002E spray tips (Teejet Tee jet Spraying Systems Co., P.O. Box 7900, Wheaton, IL 60188) calibrated to deliver 93 L/ha at 207 kPa was used. Herbicides were applied when sesame was 38 to 76 cm in height. It would be better to give treatments in the form of table in 3 columns eg common name, trade name and dose. Company detail should remain in text.

2.4 Sesame varieties, planting, and harvesting. Sesame variety in 2006 was S29 while in 2007, S32 was planted at both locations. Planting dates at the Uvalde location was late May in 2006 and early June in 2007 while at the Lorenzo location, sesame was planted

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mid-June in both years. Each sesame cultivar was seeded approximately 1.0 cm deep at 3.4 kg/ha at both locations. At maturity, sesame in the plots was hand-harvested, dried for how many days and at what temperature?, and threshed with a harvester.

2.5 Data analysis. The treatment design was a factorial arrangement using a randomized complete block design with herbicides and ~~DPEPDIR~~ spray height as factors. see sec.2.2 I think it is repition An analysis of variance was performed using the ANOVA procedure for SAS (SAS Institute. 1998. SAS user's guide. SAS Inst., Cary, NC.) to evaluate the significance of herbicides and spray height on sesame response and yield. The Fishers Protected LSD at the 0.05 level of probability was used for separation of mean differences.

3.0 Results

Since there was a treatment by location or year interaction for sesame stunting and yield, data by location and year is presented separately. Data was not collected in Uvalde in 2006 due to uneven distribution of irrigation water which resulted in inconsistent plant growth and sesame development.

3.1 High Plains (Lorenzo).

3.1.1 Sesame stunt. In 2006, glyphosate and pyrithiobac applied to the 15 cm stem height resulted in 28 and 42% sesame stunting, respectively. When applied up to the 5 cm sesame stem height, stunting was no greater than 15% with either herbicide (Table 1). Glyphosate is cleared in the US for use in sesame as a ~~burndown~~ burn down, with wiper applicators, and using hooded sprayers in row middles [21]. For ~~burndown~~ burn down use, glyphosate should be applied before, during, or just after planting but before the sesame seedlings emerge. Glyphosate applied POST to sesame will result in plant death

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or yellowing and a lack of capsule formation for one to three weeks [21]. When capsule formation does somewhat recover, the capsules will be smaller and contain less seeds and have a reduced seed weight. Glyphosate plus diuron stunted sesame 10% when applied up to 15 cm; however, no other herbicides stunted sesame more than 4% when applied to sesame at either height (Table 1). In Venezuela, diuron at 0.6 and 1.2 kg/ha applied pre-emergence reduced sesame yield, but yield would have been much lower without weed control [22]. In the U.S., in one year, diuron at 0.8 and 1.7 kg/ha applied pre-emergence resulted in adequate weed control without apparent crop injury whereas in another year, there was stand reduction and chorosis [23]. ~~In later work by~~ Grichar et al. [18], ~~they~~ reported that diuron at 1.12 kg/ha reduced sesame stands and caused injury in one year in the Texas High Plains area; however, in south Texas no adverse effects with diuron were seen in the two years.

In 2007, sesame stunting was more severe with glyphosate, glufosinate, pyriithiobac, and trifloxysulfuron applied up to 15 cm ~~in~~ sesame height compared with applications made up to 5 cm ~~in~~ height (Table 1). Only glufosinate-ammonium, pyraflufen-ethyl, linuron + diuron, and linuron applied up to 5 cm caused less than 10% sesame stunting. Pyriithiobac caused the greatest sesame stunting whether applied up to 5 or 15 cm sesame.

3.1.2 Sesame yield. In 2006, glyphosate or paraquat applied up to the 15 cm height, resulted in a yield reduction when compared with applications made to lower stem height (Table 1). Trifloxysulfuron plus prometryn reduced yield when applied up to 5 cm height but not up to the 15 cm height while lactofen, pyriithiobac, and glyphosate plus either prometryn or diuron reduced sesame yield regardless of application height. Although sesame stunting appeared greater in 2007, not as many herbicides caused a reduction in

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yield from the non-treated control as 2006. Pyriithiobac and trifloxysulfuron applied to sesame at either height and glyphosate applied up to 15 cm sesame reduced yield when compared to the non-treated control. Glyphosate applied up to 15 cm sesame reduced yield; however, the application made up to 5 cm on sesame stem did not.

3.2 South Texas

3.2.1 Sesame stunt. In 2007, glyphosate, glufosinate-ammonium, paraquat, lactofen, pyriithiobac, trifloxysulfuron, and glyphosate plus diuron caused greater sesame stunting when applied to the sesame stem up to the 15 cm height than the 5 cm height (Table 1). Pyraflufen-ethyl, trifloxysulfuron + prometryn, linuron + diuron, linuron alone, propazine, and glyphosate + prometryn applied either up to 5 or 15 cm resulted in sesame stunting that was not different from the untreated check.

Pre-emergence applications of prometryn at 0.5 kg/ha caused no sesame injury, but prometryn applied pre-plant incorporated almost completely wiped out the sesame (D. Howell, unpublished data). Prometryn at 0.6 and 1.1 kg/ha resulted in lower sesame populations, lowered plant height, and also reduced yields compared with *S*-metolachlor at 1.1 or 2.2 kg/ha [24]. However, in a later study in south Texas and the Texas High Plains, prometryn injured sesame but yields were not reduced from that of *S*-metolachlor [18].

3.2.2 Sesame yield. Glyphosate, glufosinate-ammonium, carfentrazone-ethyl, paraquat, and trifloxysulfuron + prometryn applied up to 5 cm did not reduce sesame yield when compared with the untreated check although these herbicides applied up to the 15 cm height did reduce yield (Table 1). Pyriithiobac, trifloxysulfuron, and glyphosate + diuron reduced sesame yield when applied at either height. The premix of linuron + diuron,

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linuron alone, pyraflufen-ethyl, or propazine resulted in little or no sesame stunting and did not affect sesame yield when applied at either height up the sesame stem. (include yield fig. and % dec. at places where necessary)

4.0 Discussion

As height of herbicide spray up the main stem of sesame increased, the chances of sesame stunting and a reduction in yield also increased. The combination of linuron + diuron produced the least sesame injury whether applied 5 or 15 cm up the sesame main stem. Work by Grichar et al. [18] reported that diuron at 1.12 kg/ha reduced sesame stands and caused sesame injury in one year in the Texas High Plains area; however, in south Texas no adverse effects with diuron were seen in the two years of research. Limited information is available on linuron use in sesame. Santelmann et al. [25] found slight phytotoxicity and a reduction in sesame yield with linuron at 2.24 kg/ha

Although glyphosate stunted sesame when applied up to the 5 cm height but it did not result in a reduction in yield. Under close examination, the sesame population was high and the glyphosate appeared to kill the less vigorous (minor) plants under the canopy and thus thinned the population. In a high population situation, the minor plants are actually a weed because they use moisture and fertility without giving commensurate yield.

Glyphosate is cleared in the U.S. for use in sesame as a burn_down, with wiper applicators, and /or hooded sprayers in row middles [21]. For burn_down use, glyphosate should be applied before, during, or just after planting but before the sesame seedlings emerge. When applied after sesame has emerged, any amount of glyphosate on a sesame plant will usually result in injury. Glyphosate applied POST to sesame will result in plant death or yellowing of the sesame and a lack of capsule formation for one to three weeks

[21]. When capsule formation does somewhat recover, the capsules will be smaller and will have less seeds and seed weight.

Glufosinate is also a nonselective POST herbicide that may have potential for use in sesame in many of the same ways that glyphosate can be used. It controls a wide range of weed species and is especially effective on some species such as ~~morningglory~~morning glory (*Ipomoea* spp.) that can be difficult to control with glyphosate [26,27,28].

Conflict of Interest

The authors declare there is no conflict of interest regarding the publication of this paper.

References

- [1] D. Bedigian and J. R. Harlan, "Evidence for cultivation of sesame in the ancient World," *Economic Botany*, vol. 40, pp. 137–154, 1986.
- [2] E. A. Weiss, "Castor, sesame, and safflower," *Leonard Hill Books*, London, p. 311–525, 1971.
- [3] E. M. Betts, "Thomas Jefferson's garden book (1766–1824)," *Thomas Jefferson Memorial Foundation, Inc.*, Charlottesville, Virginia, 1999.
- [4] R. D. Brigham and J. K. Young, "Sesame performance tests, Lubbock, 1979," *Texas Agricultural Experiment Station Progress Report 3688*, 1982.
- [5] D. R. Langham and T. Wiemers, "Progress in mechanizing sesame in the US through breeding," in *Trends in new crops and new uses*, J. Janick and A. Whipkey, Eds., pp. 157-173, ASHS Press, Alexandria, VA, 2002.
- [6] D. R. Langham, "Phenology of sesame," in *Issues in New Crops and New Uses*, J. Janick and A. Whipkey Eds., pp. 144-182, ASHS Press, Alexandria, VA, 2007.
- [7] M. J. Kropff and C. J. T. Spitters, "A simple model of crop loss by weed

competition from early observations on relative leaf area of weeds,” *Weed Research*,
vol. 31, pp. 97-105, 1991.

[8] R. S. Balyan, “Integrated weed management in oilseed crops in India,” *Indian
Society of Weed Science*, vol. 1, pp. 317-323, 1993.

[9] A. M. Gurnah, “Critical weed competition periods in annual crops,” *Proceedings
Fifth East African Weed Control Conference*, Nairobi, Kenya, pp. 89-98, 1974.

[10] D. Singh, J. C. Dagar, and B. Gangwar, “Infestation by weeds and their
management in oilseed crops – a review,” *Agricultural Review*, vol. 13, pp. 163-
175, 1992.

[11] U. C. Upadhyay, “Weed management in oilseed crops,” in *Oilseed
Production Constraints and Opportunities*, H. C. Srivastava, S. Bhaskaran, B. Vatsya,
K.K.G. Menon, Eds, New Delhi, Oxford & IBH Publishing Company, pp. 491-
499, 1985.

[12] G. Eagleton, S. Sandover, and M. Dickson, “Research report:sesame seed 1982-
1986,” *Kununrra Regional Office, Department of Agriculture*, Western Australia, 1987.

[13] M. Bennett, “Sesame Research Report 1991-92. Wet season, Katherine. Northern
Territory”, *Australian Dept. of Primary Industries and Fisheries*, Technical Bulletin
No. 215, 1993.

[14] D. R. Langham, “Growth and Development of Sesame,” *Sesaco Corporation*, 42 p.,
2008.

[15] D. R. Langham, J. Riney, G. Smith, T. Wiemers, “Sesame Grower Guide.
Sesaco Corporation, 30 p., 2008.

[16] G. N. Schrodter and J. E. Rawson, “Herbicide evaluation studies in sesame,”

- 1 *Australian Weeds*, vol. 3, pp. 47-49, 1984.
- 2 [17] W. J. Grichar, D. C. Sestak, K. D. Brewer, B. A. Besler, C. R. Stichler, and D. T.
- 3 Smith, "Sesame (*Sesamum indicum* L.) tolerance with various postemergence
- 4 Herbicides," *Crop Protection*, vol. 20, pp. 685-689, 2001.
- 5 [18] W. J. Grichar, P. A. Dotray, and D. R. Langham, "Sesame (*Sesamum indicum*
- 6 L.) response to preemergence herbicides," *Crop Protection*, vol. 28, pp. 928-933,
- 7 2009.
- 8 [19] W. J. Grichar, P. A. Dotray, and D. R. Langham, "Weed control and the use of
- 9 herbicides in sesame production," in *Herbicides, Theory and Applications*, S.
- 10 Soloneski and M. L. Larramendy, Eds., ISBN: 978-953-307-975-2, InTech,
- 11 Available from: [http://www.intechopen.com/articles/show/title/weed-control-and-](http://www.intechopen.com/articles/show/title/weed-control-and-the-use-of-herbicides-in-sesame-production)
- 12 the-use-of-herbicides-in-sesame-production, 2011.
- 13 [20] W. J. Grichar and P. A. Dotray, "Weed control and sesame (*Sesamum indicum*
- 14 L.) response to preplant incorporated herbicides and method of incorporation," *Crop*
- 15 *Protection*, vol. 26, pp. 1826-1830, 2007.
- 16 [21] D. Langham, J. Riney, G. Smith, T. Wiemers, D. Peeper, and T. Speed, "Sesame
- 17 Producers Guide," *Sesaco Corporation*, 33 p., 2010.
- 18 [22] B. Mazzani, "Mejoramiento del ajonjolí en Venezuela," *Ministerio de*
- 19 *Agricultura y Cria*, Maracay, Venezuela, p. 127, 1957.
- 20 [23] T. W. Culp and G. G. McWhorter, "Annual report of cooperative industrial
- 21 crops and weed investigations-1959," *Crops Research Division*, ARS, USDA,
- 22 Stoneville, MS., 1959.
- 23 [24] W. J. Grichar, D. C. Sestak, K. D. Brewer, B. A. Besler, C. R. Stichler, and D. T.

- 1 Smith, "Sesame (*Sesamum indicum* L.) tolerance and weed control with soil-
- 2 applied herbicides," *Crop Protection*, vol. 20, pp. 389-394, 2001.
- 3 [25] P. Santelmann, W. Elder, and R. Murlock, "The effect of several pre-emergence
- 4 herbicides on guar, cowpeas, mungbeans, and sesame," *Proceedings Southern*
- 5 *Weed Science Society*, vol. 16, pp. 83, 1963.
- 6 [26] S. Askew, D. Shaw, and J. Arnold, "Weed control in Liberty-Link soybean.
- 7 *Proceedings Southern Weed Science Society*, vol. 50, p. 59, 1997.
- 8 [27] J. Corbett, S. Askew, W. Thomas, and J. Wilcut, "Weed efficacy evaluations for
- 9 bromoxynil, glufosinate, glyphosate, pyriithiobac, and sulfosate," *Weed Technology*,
- 10 vol. 18, pp. 443-453, 2004.
- 11 [28] D. Hydrick and D. Shaw, "Non-selective and selective herbicide combinations in
- 12 stale seedbed soybean (*Glycine max*)," *Weed Technology*, vol. 9, pp. 158-165, 1995.

~~post-emergence-directed~~ herbicides sprays.^{a,b}

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			Lorenzo					
			Stunt		Yield		Uvalde ^c	
Treatment	Rate	Height ^d	2006	2007	2006	2007	Stunt	Yield
		cm	— % —	—	— kg/ha —		%	kg/ha
Non-treated	-	-	0	0	612	810	0	1223
Glyphosate	0.84	5	12	18	526	830	20	984
		15	28	50	268	399	90	426
Glufosinate-ammonium	0.58	5	2	8	556	1047	7	1173
		15	4	27	538	754	45	786
Carfentrazone-ethyl	0.02	5	0	22	608	1080	24	996
		15	3	19	540	777	37	654
Pyraflufen-ethyl	0.002	5	2	9	588	1068	0	1446

1			15	3	15	582	1015	2	-
2	Paraquat	0.28	5	0	13	630	1014	5	1062
3			15	0	15	516	963	30	705
4	Lactofen	0.22	5	0	20	494	882	13	1191
5			15	2	19	452	812	38	1194
6	Pyrithiobac	0.07	5	15	52	412	298	65	345
7			15	42	67	392	117	85	129
8	Trifloxysulfuron	0.008	5	0	27	588	477	20	687
9			15	5	47	528	468	57	273
10	Trifloxysulfuron	0.008	5	0	22	520	690	10	1194
11	+ prometryn	+ 1.12	15	2	33	574	942	17	933
12	Linuron	0.56	5	2	7	552	567	8	1386
13	+ diuron	0.56	15	0	11	540	1005	0	1215
14	Linuron	1.12	5	-	8	-	1046	0	1272
15			15	-	18	-	1014	7	1068
16	Propazine	1.12	5	-	19	-	750	0	1317
17			15	-	18	-	822	0	1272
18	Glyphosate	0.84	5	0	13	462	964	2	1440
19	+ prometryn	1.12	15	3	17	398	843	1	1425
20	Glyphosate	0.84	5	2	17	382	760	12	917
21	+ diuron	1.12	15	10	28	280	611	35	773
22	LSD (0.05)			5	15	90	210	17	264

23 ^a All POST herbicides, except glufosinate, included a non-ionic surfactant at 0.25 % v/v

1 or a crop oil concentrate at 1.0 % v/v.

2 ^b Stunt ratings taken approximately 30 d after herbicide application.

3 ^c Uvalde data for 2007 only.

4 ^d Height that herbicides sprays reached up the main stem of sesame.

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