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# Evaluation of Diserbone E 72, Stard 600 SL, and 2, 4-D Ester (2, 4-D) for Weeds Control in Sorghum

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***Abstract:*** **This experiment was carried out, during season 2011/2012, at two locations, Northern Gedarif in rainfed condition, and at Sennar Agricultural Research Station Farm under irrigation system, to evaluate the efficacy and selectivity of post- emergence application of Diserbone E 72, Stard 600 SL, and 2, 4-D Ester (new formulations of 2, 4-D) each at 0.32 kg a.e. / fed, on weeds control in sorghum. The tested herbicides gave moderate to excellent control (56 – 95 %) of broadleaved weeds throughout the season and poor efficacy against grassy weeds in both locations. They also significantly reduced weed biomass in comparison to their respective control. Unrestricted weed growth reduced sorghum grain yield by 20 - 28%. Diserbone E 72, Stard 600 SL and 2, 4-D Ester outyielded the unweeded control and resulted in grain yield comparable to the counterpart Dicopur 720 SL. The $R_f$ value of 2, 4-D standard was 0.86, the minimum detectable quantity was 0.04 µg and the recovery of the method was 84%. No residues of 2, 4-D were detected in all samples. The maximum residue limit (MRL) of 2, 4-D in sorghum is 2 mg/kg.**

***Keywords:*** **Rainfed, Formulations, Counterpart, Broadleaved, Handweeding, Unweeded.**

## I. INTRODUCTION

Sorghum, (*Sorghum bicolor* (L.) Moench), is one of the most important cereal crops in Africa. In Sudan, sorghum is widely grown in the irrigated and rainfed sectors (Abdelgadir *et al*. 2009) [1]. The estimated total area under sorghum ranged between 4.3 and 7.1 million ha with an average of 5.2 million ha producing over three million metric tons of grain (Noureldin and El amin, 2006)[2]. Sorghum is a staple food for about 300 million people who live in the dry tropics. The crop not only provides grain for human consumption, but the leaves and stems are also used as forage for livestock, as building materials and fuel for cooking. In industrialized countries, sorghum is generally used as animal feed (Chantereau and Nicou, 1994) [3]. Weeds are considered as one of the major limiting factor to its productivity. Sorghum grain yield loss due to weed competition was estimated to be 20 – 80 % (Hamdoun *et al*. 1979) [4]. The problem of weeds is more serious in the rainfed sector because of its extended area and prevalence of rains during the critical period of weed competition that hinder weeding at the right time thus yield is drastically affected. This condition makes chemical control as one of economically feasible option. 2,4-dichlorophenoxy-acetic acid (2,4-D) belongs to the phenoxy acid group, that mimic the endogenous plant hormone indolyl -3-acetic acid (IAA) (Green *et al.*, 1979)[5]. The herbicide is used in form of the parent acid or more commonly as salts and esters. It is absorbed more rapidly through foliage; a rain-free period of 4 h is usually adequate for uptake and effective weed control (Ashton and Grafts, 1981) [6]. The herbicide causes dedifferentiation and initiation of cell division in mature cells, inhibition of cell division in the primary meristems of intact plants and promotion of cell elongation in shoot tissue but its inhibition in roots (Ashton and Grafts, 1981) [6]. Death of susceptible plants occurs slowly, usually within 3-5 weeks. In Sudan, different formulation of 2, 4-D, have been recommended at 0.32 kg a.e /fed, as post- emergence treatment for broadleaved weeds and *Striga hermonthica* (Del.) Benth. control in sorghum. 2,4-D is used for broadleaved weeds control at 0.6 kg a.e /fed in wheat (Ahmed *et al.*,

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2010)[7]. Our experiment was set to evaluate the efficacy and selectivity of new formulations of 2, 4- D (Diserbone E 72, Stard 600 SL, and 2, 4-D Ester) for broadleaved weed control in sorghum.

## II. MATERIALS AND METHODS

Sorghum cv. "Arfa Gadamak – 8" and "Wad Ahmed" were sown, on third week of July 2011, at the demonstration farm of Gedarif University (DFGU) in northern Gedarif, Sudan (Latitude N 14°.33˜, Longitude E 35°.36˜, and Elevation 540 m above sea level) and Sennar (Latitude N 13°.30˜, Longitude E 33°.57˜) respectively. The crop was sown on flat (in Gedarif) and ridges (in Sennar) at inter- and intra-row spacing of 80 and 20 cm, respectively. Urea was applied as basal dose at 40 and 80 kg/fed at Gedarif and Sennar, respectively. The plants were thinned to 2 plants / hole 2 weeks after sowing. The herbicides, Diserbone E 72, (2, 4-D amine 72%) (dichlorophenoxy acetic acid), is produced by Chemia S.P.A Italy and introduced to Sudan by Green Arcades(s) Co. Ltd, Khartoum. Stard 600 SL (2, 4-D amine 72%) (dichlorophenoxy acetic acid), is produced by Hangzhou Yilong Chemical Industry Co. Ltd and introduced to Sudan by Tabarak Marketing Co Ltd, Khartoum., and 2, 4-D Ester (2, 4-D amine 72%) (dichlorophenoxy acetic acid), is produced by Arabian Company for Pesticides Industry and Veterinary Drugs. Jordon and introduced to Sudan by Farmer Investment Co Ltd, Khartoum. The counterpart Dicopur 720 SL (2, 4-D amine 72%) (dichlorophenoxy acetic acid), is produced by Nufarm Pflanzenschutz GMBH & Co. KG, Austria and introduce into the Sudan by their agent The Central Trading Co. LTD, each at 0.32 kg a.e./fed, were sprayed, 3 weeks after sowing, with Knapsack sprayer at a volume rate of 105 and 150L / fed, at Gedarif and Sennar, respectively. At Sennar, there was a rain (64 mm) 8 hrs after herbicides application. Weeded and unweeded control plots were included for comparison. Weeded plots received three handweedings at biweekly intervals starting after sowing. Some of the herbicides treatments received a supplementary handweeding 4 weeks after application (WAA). Treatments were arranged in a randomized complete block design with four replicates. Treatments effects were assessed by counting total and individual weed species and weed ground cover in 4 fixed quadrates (40 X 25cm) 4 and 8 weeks after herbicides application (WAA). Man-hours required for supplementary handweeding and weed biomass were recorded at Sennar site. Plant population and grain yield were determined at harvest. Collected Data were subjected to analysis of variance.

Duplicate samples (50g each) of sorghum were crushed in a mortar. Soxhlet extraction was carried out with 150 ml methanol for 3 hrs. The methanol extract was filtered and evaporated by vacuum rotary evaporator to near dryness. The extracts were cleaned-up by chromatographic column filled with 20 g deactivated Florisil and eluted with 50 ml methanol. The eluate was concentrated to dryness and the residues were taken into 2 ml methanol. Concentrated samples and 2,4-D standard were spotting in thin –layer chromatography (TLC), on ready- made silica gel GF254 coated plates. The plates were developed in a solvent system of methanol. Residues of 2, 4- D were determined under UV radiation at the wavelength 254 nm.

## III. RESULTS

***A. Effects on Weeds:*** At Gedarif, the number of weeds in the unweeded control 4 and 8 WAA were 323 and 292 plant / $m^2$, respectively. Broadleaved weeds and grasses represented 86 and 14 % of the total weeds, respectively. Dominant weeds were *Striga hermonthica* (23.2 %), *Corchorus* spp (15.8 %) *Acalypha indica* (13.3 %) *Sorghum sudanense* (11%), *Desmodium dichotomum* (10.2 %) and *Vernonia amygdalina* (8.3%).

At Sennar, the number of weeds in the unweeded control 4 and 8 WAA were 231 and 217 plants / $m^2$, respectively. Broadleaved weeds and grasses represented 87 and 13 % of the total weeds, respectively. Dominants weeds were *Corchorus* spp (28 %), *Acalypha indica* (16 %), *Panicum hygrocharis* (13 %) *Abutilon glaucum* (12 %) *Brachiaria eruciformis* (11%) and *Phyllanthus niruri* (10 %). Dominant weeds and their reactions to different treatments were presented in Tables 1 and 2.

At Gedarif, Diserbone E 72, Stard 600 SL, 2, 4-D Ester and the counterpart Dicopur 720 SL resulted in (52 - 95 %) control of the broadleaved weeds, but had no effects on grasses, throughout the season (Table 3). When the tested products were supplemented with handweeding they resulted in more than 75 % control of both broadleaved and grasses. Herbicides treatments without supplementary handweeding, reduced weed ground cover by more than 74 and 40 % in comparison to the unweeded control, 4 and 8 WAA, respectively. However, 95 % ground cover reduction was obtained when the herbicides treatments were supplemented with handweeding (Table 3). Weeds biomass in the unweeded control

was 67.7g / $m^2$ (Table 5). The tested herbicides reduced weed biomass by 37 – 66 %, however, when the products were supplemented with handweeding, further reductions (50 – 83 %) in weed biomass were obtained.

At Sennar, Diserbone E 72, Stard 600 SL, and 2,4-D Ester and the counterpart Dicopur 720 SL resulted in moderate to excellent control of the broadleaved weeds (54 - 86 %) throughout the season (Table 4). When supplemented with one handweeding, the tested products achieved 100 % control of broadleaved weeds. Herbicides treatments have no influence on grasses throughout the season. The tested products and the counterpart, reduced weed ground cover by 5 and 3 %, 4 and 8 WAA in comparison to the unweeded control, respectively. However, 100 % ground cover reduction was obtained when herbicides treatments were supplemented with handweeding (Table 4). The time required for supplementary handweeding in the weeded control was 144 h / fed (Table 6). The herbicides significantly reduced the time required for supplementary weeding in comparison to the weeded control. Weed biomass in unweeded control was 750 g / $m^2$ (Table 6). The tested herbicides significantly reduced weed biomass in comparison to unweeded control except Stard and the standard Dicopur without supplementary handweeding.

***B. Effects on Crop:*** No visible phytotoxic symptoms on sorghum plants were noticed. Plant population were 33-46 and 40- 53 (000) plants / fed at Gedarif and Sennar, respectively (Tables 5 & 6). At Gedarif, unrestricted weed growth reduced plant population by 24 % (Table 5). The tested products resulted in a comparable plant population in comparison to the weeded control except 2,4-D Ester without supplementary handweeding.

At Sennar, there was no significant difference in plant population when compared to the unweeded control (Table 6). However, a significant reduction in plant population between 2,4-D Ester and Dicopur with or without supplementary handweeding were found when compared to the weeded control.

Sorghum grain yield in the weeded control was 0.14 and 2.14 t / fed at Gedarif and Sennar, respectively (Tables 5 & 6). Unrestricted weed growth reduced sorghum grain yield by 79 and 71 % at Gedarif and Sennar, respectively. At Gedarif, the tested herbicides, with or without supplementary handweeding, increased sorghum grain yield by one fold in comparison to the unweeded control. However, at Sennar they outyielded the unweeded control and resulted in grain yield comparable to that obtained by the weeded control.

***C. Residue analysis:*** The $R_f$ value of 2, 4-D standard was 0.86, the minimum detectable quantity was 0.04 µg and the recovery of the method was 84%. No residues of 2, 4-D were detected in all samples. The maximum residue limit (MRL) of 2, 4-D in sorghum is 2 mg/kg.

## IV. DISCUSSION

Dominant weeds on both, Gedarif and Sennar sites were broadleaved weed (more than 85) and the rest were Grasses. The tested products, Diserbone E 72, Stard 600 SL and 2, 4-D Ester, formulations of 2, 4-D, resulted in moderate to excellent control of broadleaved weeds (53- 95 %) (Tables 3 and 4). This finding corroborates the observation reported by Ahmed. *et al.,* (2010)[7] that different 2, 4-D formulations resulted in excellent control of broadleaved weed. The tested products have no influence on grass throughout the season. This was in lined with several reports on the efficacy of 2,4-D on grasses (Awad. *et al.,* 2011)[8]. The tested products followed by one supplementary handweeding resulted in excellent and persistent control of broadleaved throughout the season (Tables 3 and 4). Magani. (2008)[9] reported that low rates of herbicide treatment, followed by supplementary hoe-weeding reduced weed infestation better than the higher herbicide rates without hoe-weeding. The herbicides used showed no visible phytotoxic symptoms on sorghum plants. This observation agrees with that of Ahmed. *et al.* (2010)[7]. Unrestricted weed growth reduced sorghum grain yield by 79 and 71 % at Gedarif and Sennar, respectively (Tables 6 and 7). Slight weed infestation at the early stages of growth may significantly reduce sorghum grain (Berenji and Dahlberg, 2004) [10]. High weed infestation with monocotyledonous species at the initial stage of crop growth causes decrease in yield by over 20 % (Kaczmarek. *et al*, 2009) [11]. No residues of 2, 4-D were detected in all grain samples tested. The results from this study suggest that the farmers can use Diserbone E 72, Stard 600 SL, and 2, 4-D Ester for weeds control in sorghum to reduce labour input, as manual labour input is one of the bottle-neck in crop production in rainfed areas of Sudan. Supplementary handweeding should be done 4 weeks after herbicide application. In order to have season long weed control this is important for obtaining an optimum yield of the crop. The use of Diserbone E 72, Stard 600 SL and 2, 4-D Ester as post-emergence treatment for the control of weeds in sorghum is safe if used at the recommended dose.

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## V. CONCLUSIONS

The herbicides, Diserbone E 72, Stard 600 SL and 2, 4-D Ester achieved weed control similar to the counterpart Dicopur 720 SL. Diserbone E 72, Stard 600 SL and 2, 4-D Ester had no adverse effects on sorghum stand. Unrestricted weed growth reduced sorghum grain yield by 79% and 71% at Gedarif and Sennar, respectively. The three tested chemicals, each at 0.32 kg a.e./fed, outyielded the unweeded control and resulted in grain yield comparable to the weeded control. The use of Diserbone E 72, Stard 600 SL and 2, 4-D Ester as post emergence treatment for the control of broadleaved weeds in sorghum is safe, if used at the recommended dose.

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## APPENDIX – A

**Table 1: Efficacy of Diserbone E 72, Stard 600 SL, and 2,4-D 41.4 EC versus Dicopur 720 SL on dominant weeds at Gedarif (4WAA).**

| | | % Weed control | | | | | |
|---|---|---|---|---|---|---|---|
| Treatment | Herbicides rate (kg a. e./ fed.) | Striga hermonthica | Corchours spp | Acalypha indica | Sorhgum sudanense | Desmodium dichotomum | Vernonia amygdalina |
| Diserbone E 72 | 0.32 | 23 | 95 | 0 | 0 | 20 | 49 |
| Stard 600 SL | 0.32 | 57 | 95 | 0 | 0 | 85 | 85 |
| 2,4-D Ester | 0.32 | 9 | 100 | 64 | 0 | 98 | 82 |
| Dicopur 720 SL | 0.32 | 36 | 68 | 43 | 0 | 0 | 49 |
| Unweeded control | 0.32 | 0 (75)* | 0 (51)* | 0 (43)* | 0 (36)* | 0 (33)* | 0 (8.3)* |

WAA = Weeks after herbicide application. * Number of individual weed species / $m^2$.

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**Table 2: Efficacy of Diserbone E 72, Stard 600 SL, and 2,4-D 41.4 versus Dicopur 720 SL on dominant weeds at Sennar (4WAA)**

| | % Weed control | | | | | | |
|---|---|---|---|---|---|---|---|
| Treatment | Herbicides rate (kg a. e./ fed.) | Corchorus spp | Acalypha indica | Panicum hygrocharis | Abutilon glaucum | Brachiaria eruciformis | Phyllanthus niruri |
| Diserbone E 72 | 0.32 | 95 | 83 | 0 | 7 | 0 | 0 |
| Stard 600 SL | 0.32 | 100 | 88 | 0 | 5 | 0 | 15 |
| 2,4-D Ester | 0.32 | 100 | 100 | 0 | 80 | 0 | 13 |
| Dicopur 720 SL | 0.32 | 99 | 72 | 0 | 18 | 0 | 0 |
| Unweeded control | 0.32 | 0 (66)* | 0 (37)* | 0 (31)* | 0 (28)* | 0 (25)* | 0 (23)* |

WAA = Weeks after herbicide application. * Number of individual weed species / $m^2$.

**Table 3: Effects of Diserbone E 72, Stard 600 SL and 2,4-D 41.4 EC on weeds control and weed ground cover in comparison to the counterpart Dicopur 720 SL. 2011/2012. Gedarif.**

| Treatment | Herbicides (rate kg a. e. / fed.) | Weed control (%) Broadleaved 4 WAA | 8 WAA | Grasses 4 WAA | 8WAA | Weed ground cover(%) 4WAA | 8WAA |
|---|---|---|---|---|---|---|---|
| Diserbone E 72 | 0.32 | 66 | 52 | 0 | 0 | 29 | 47 |
| Diserbone E 72 + | 0.32 | 66 | 82 | 0 | 99 | 29 | 3 |
| Stard 600 SL | 0.32 | 83 | 60 | 0 | 0 | 22 | 6 |
| Stard 600 SL + | 0.32 | 83 | 76 | 0 | 100 | 22 | 4 |
| 2,4-D Ester | 0.32 | 95 | 77 | 0 | 0 | 13 | 6 |
| 2,4-D Ester + | 0.32 | 95 | 84 | 0 | 97 | 13 | 4 |
| Dicopur 720 SL | 0.32 | 55 | 70 | 0 | 0 | 28 | 6 |
| Dicopur 720 SL + | 0.32 | 55 | 87 | 0 | 99 | 28 | 2 |
| Weeded control | | 100 | 100 | 100 | 100 | 0 | 0 |
| Unweeded control | | 0 | 0 | 0 | 0 | 88 | 77 |

+ With supplementary hand weeding. WAA= Weeks after application.

**Table 4: Effects of Diserbone E 72, Stard 600 SL and 2,4-D 41.4 EC on weeds control and weed ground cover in comparison to the counterpart Dicopur 720 SL at Sennar.**

| Treatment | Herbicides rate (kg a.e./fed.) | % Weed control Broadleaved 4 WAA | 8 WAA | Grasses 4 WAA | 8 WAA | % Weed ground cover 4WAA | 8WAA |
|---|---|---|---|---|---|---|---|
| Diserbone E 72 | 0.32 | 56 | 62 | 0 | 0 | 49 | 59 |
| Diserbone E 72 + | 0.32 | 56 | 100 | 0 | 100 | 49 | 0 |
| Stard 600 SL | 0.32 | 68 | 83 | 0 | 0 | 54 | 64 |
| Stard 600 SL + | 0.32 | 68 | 100 | 0 | 100 | 54 | 0 |
| 2,4-D Ester | 0.32 | 83 | 86 | 0 | 0 | 50 | 48 |
| 2,4-D Ester + | 0.32 | 83 | 100 | 0 | 100 | 50 | 0 |
| Dicopur 720 SL | 0.32 | 54 | 60 | 0 | 0 | 60 | 53 |
| Dicopur 720 SL + | 0.32 | 54 | 100 | 0 | 100 | 60 | 0 |
| Weeded control | | - | - | - | - | 0 | 0 |
| Unweeded control | | - | - | - | - | 63 | 66 |

+ With supplementary hand weeding. WAA= Weeks after application.

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**Table 5: Effects of Diserbone E 72, Stard 600 SL and 2,4-D 41.4 EC versus the counterpart Dicopur 720 SL on man-hours, weed biomass, plant population and sorghum grain yield at Gedarif.**

| Treatment | Herbicides rate (kg a. e. / fed.) | Weed biomass ($g/m^2$) | Plant population (000/ fed.) | Grain yield (t/fed.) |
|---|---|---|---|---|
| Diserbone E 72 | 0.32 | 24. bc | 46 a | 0.06 cd |
| Diserbone E 72 + | 0.32 | 20 bc | 36 abc | 0.09 abcd |
| Stard 600 SL | 0.32 | 40 abc | 38 abc | 0.06 cd |
| Stard 600 SL + | 0.32 | 34 bc | 44 ab | 0.13 abc |
| 2,4-D Ester | 0.32 | 23 bc | 33 c | 0.06 bcd |
| 2,4-D Ester + | 0.32 | 19 bc | 38 abc | 0.15 a |
| Dicopur 720 SL | 0.32 | 43ab | 37 abc | 0.06 bcd |
| Dicopur 720 SL + | 0.32 | 12 c | 36 abc | 0.06 bcd |
| Weeded control | | 11 c | 45 a | 0.14 ab |
| Unweeded control | | 68 a | 34 bc | 0.03 d |
| SE ± | | 8.6 | 3.07 | 0.02 |
| CV % | | 41.6 | 19.91 | 54.77 |

+ With supplementary hand weeding. In each parameters, figures followed by the same letter (s) are not significantly different, according to Duncan's Multiple Range Test at $P \leq 0.05$.

**Table 6: Effects of Diserbone E 72, Stard 600 SL and 2,4-D 41.4 EC versus the counterpart Dicopur 720 SL on man-hours, weed biomass, plant population and sorghum grain yield at Sennar.**

| Treatment | Herbicides rate (kg a. e. / fed.) | Man-hours/ fed. | Weed biomass ($g/m^2$) | Plant population (000/ fed.) | Grain yield (t/fed.) |
|---|---|---|---|---|---|
| Diserbone E 72 | 0.32 | - | (255) 14.6 bcd | 49ab | 1.36bc |
| Diserbone E 72 + | 0.32 | 76 b | (148) 9.7 cd | 47abc | 1.49bc |
| Stard 600 SL | 0.32 | - | (425) 20.6 ab | 43ab | 1.14c |
| Stard 600 SL + | 0.32 | 103 b | (80) 8.7 cde | 53a | 1.49bc |
| 2,4-D Ester | 0.32 | - | (272) 16.2 bc | 45bc | 1.49bc |
| 2,4-D Ester + | 0.32 | 80 b | (233) 13.0 bcd | 40c | 1.61b |
| Dicopur 720 SL | 0.32 | - | (475) 21.4 ab | 44bc | 1.69b |
| Dicopur 720 SL + | 0.32 | 100 b | (45) 6.4 de | 44bc | 1.60bc |
| Weeded control | | 144 a | (0.0) 0.7 e | 53a | 2.14a |
| Unweeded control | | - | (750) 27.3 a | 46abc | 0.62 d |
| SE ± | | 13.2 | 27 | 2.37 | 0.14 |
| CV % | | 26.1 | 39.3 | 10.2 | 19.1 |

+ With supplementary hand weeding. Actual data in parenthesis, Data transformed to ($\sqrt{x} + 0.5$). In each parameters, figures followed by the same letter (s) are not significantly different, according to Duncan's Multiple Range Test at $P \leq 0.05$ .