Effects of hand weeding frequencies and herbicide application on sunflower yields and incomes in Uganda

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Abstract

Weed management trials in sunflower were conducted at the National Semi Arid Resources Research Institute (NaSARRI) in 2010, 2011 and 2012. Hand weeding started at 15, 30 and 45 days after planting (dap) and the weeding frequencies were once, twice or thrice. A herbicide called Select of the cloheaxanedione family and with clethodim as the active ingredient was also applied to some plots at 100 mls/15 litres of water once at 15 dap, and twice at 15 and 30 dap. Numbers of weed species and their counts were taken regularly before and one week after treatment applications. Data was recorded on sunflower growth parameters such as height, stem and head diameters. Sunflower was harvested from the four middle rows, threshed, dried winnowed, weighed and yields calculated. Costs involved in the various weed management treatments were recorded and weed control margins calculated.

Data from this study emphasize that sunflower must be weeded, and weeding should start at, or around 15 dap but not exceed 45 dap. The earlier one starts to weed, the better the performance and more delays lead to reductions in yields. Starting to weed at 15, 30 and 45 dap increased yields by 58.8, 42.9 and 40.4 % over the non weeded controls, while application of Select once or twice increased yields by only 10.9 and 10.6 % respectively. To maximize incomes and weeding margins in sunflower, weeding should be done once.

The herbicide (Select) significantly reduced counts of grass weeds but had insignificant effects on broad leafed weeds. Yields, incomes and costs associated with its use whether once or twice do not justify its recommendation for sole use on sunflower in Uganda.

Introduction

Sunflower (*Helianthus annuus* L.) is an introduced crop that has fitted well in the farming systems of Africa. In Uganda it is grown by small scale farmers who handle many other food crops in any one season. It is considered a cash crop which is replacing or competing with cotton (*Gossypium hirsutum* L.) in the areas where the latter has commonly been grown. Among the reasons for decline in cotton production, hence making way for sunflower in such areas is labour intensiveness especially during weeding. Sunflower is important as a source of edible oil and cash to the growers. Edible oil production and trade World wide has mainly been from oil palm (55.8%) and soybeans (19.3%), followed by sunflower (7.3%) but these remain inadequate to sustain the demand of the growing World population (FAO, 2003). Oil from sunflower is considered premium because of its light colour, mild flavor, low saturated fat levels and the ability to withstand high cooking temperatures (Olowe and Adebimpe, 2009).

Research on sunflower in Uganda is geared towards increasing household incomes, alleviating poverty among the rural poor farmers and to produce sufficient seed for the producers and oil millers. This is in line with Uganda's government policy of Plan for Modernization of Agriculture (PMA). Sunflower has, therefore, become one of the most profitable crops in Uganda especially in the north-eastern and northern parts of the country where much of it is being grown. In the north, small and large-scale processing companies have established themselves throughout the region, in particular for sunflower, cotton, sesame and groundnuts (Ministry of Agriculture, Animal Industry and Fisheries, 2010).

The area under production in Uganda has been increasing from mid-1990s. This is partly due to the number of oil mills installed in areas where sunflower is grown. For example, there were more than 18 oil mills in the Northern town of Lira by 2002 (Prem Bindraban *et al*., 2006). Despite the increasing production in the country, the yields have remained low at farmers' levels. The main factors that have caused low yields are lack of high yielding varieties/hybrids, poor agronomic practices, inability of farmers to use agricultural inputs like fertilizers and to plant large acreages. The average yields of sunflower in farmers' fields are about 750-900 kg/ha whereas yields of the best open pollinated varieties at NaSAARI are about 1,500-2,000 kg/ha under good management while those of hybrids can reach 3,000 kg/ha, (NARO Report, 1999-2000).

Sunflower is a fast growing crop maturing in 80-120 days compared to cotton (120-150 days). It has a better potential to suppress many of the common weeds, however, due to the tropical nature of most of the sunflower growing areas in Uganda, the crop faces stiff competition from a number of broad leafed and grass weeds. Competition is critical at early stages of growth and if not checked, affects yields and quality. Weeds reduce yields by 18.6-36.3 % (Singh and Giri (2001) but losses of up to 81 % have been reported (Jaykumar, *et al*, 1988). Weeds extract nutrients from the soil, denying the crop access to the nutrients. Weed infestation in sunflower removed 48.2 kg N and 14.4 kg P/ha (Wanjari, *et a*l, 2001) as compared to 21.4 kg N and 3.4 kg P/ha in soybean (Pandya, *et*

al. 2005). Weed presence caused a yield daily loss of 1.1 and 2.5 kg ha^1 of oil yield and seed yield, respectively, whereas weed absence provided a daily gain of 6.5 kg ha^1 for oil yield and 14.4 kg ha^{-1} for seed yield. Weed crop coexistence for up to 21 days after emergence (dae) did not cause any negative effect on oil and seed yields, and the maximum length of time in which the weeds had to be controlled to prevent crop yield losses was 30 dae. The critical period of interference was from 21 to 30 dae (Brighenti, et al 2004).

There are yet no herbicides recommended for use to control weeds on sunflower in Uganda. In several sunflower growing regions, however, a number of herbicides have been recommended and are in use. Frank Whittemore (2010) describes a number of herbicides used in USA. These include pre-emergence herbicides such as *Dual Magnum* (S-metolachlor) for control of broadleaf weeds, sedges and annual grasses; *Prowl* for the control of mainly small-seeded broadleaf weeds and annual grasses; *Treflan HFP* for the control of broadleaf weeds and grasses, especially in loamy soils with a high sand content; *Ethalfluralin* (sold under the name *Sonalan*) for control of annual grasses and broadleaf weeds in a variety of soil conditions. Post-emergent herbicides include *Select, Imazamox (*commonly known as *Beyond)* and *Poast.* These herbicides are mainly for the control of grasses, with *Poast* particularly effective against annual grasses when they are from 2 to 4 inches tall. Several effective grass herbicides are registered in Australia (Vikki Osteen *et al*, 2003). They include *Fluazifop (Fusilade®), Haloxyfop (Verdict®)* and more. Few registrations for broad-leaf weed control include *Trifluralin, Paraquat (Gramoxone®)* and *Pendimethalin (Stomp).*

Weeding using the hand hoe is the only method of weed control available to Ugandan farmers but the cost of hand weeding is becoming so high due to the rapidly growing rural-urban migration. At the start of any season, the available household labour has to be split to the various crop enterprises. This makes some farmers start weeding sunflower late, resulting to poor yields and incomes. An understanding of when to start weeding and the frequency to weed will add to the profitability of the crop in Uganda. This will lead many farmers to go for larger acreages than they currently cultivate, hence increasing production of the crop. The result will be increased oil consumption, improved nutrition and higher incomes for farmers, together with bigger export volumes making a greater contribution to National Gross Domestic Product (GDP).

The objectives of this study were therefore to:

1. Determine the optimum time to start hand weeding sunflower in Uganda.
2. Establish the frequency for hand weeding.
3. Test the profitability of herbicide use on sunflower cultivation in Uganda.

Materials and Methods

Weed management trials in sunflower were conducted at the National Semi Arid Resources Research Institute (NaSARRI, 01° 31' N; 33° 27' E; 114 m above sea level) in

2010, 2011 and 2012. Twelve treatments were studied during the two seasons and they included:

1. No weeding at all
2. Hand weeding once at 15 days after planting (dap)
3. Hand weeding twice at 15 and 30 dap
4. Hand weeding thrice at 15, 30 and 45 dap
5. Hand weeding once at 30 dap
6. Hand weeding twice at 30 and 45 dap
7. Hand weeding once at 45 dap
8. Hand weeding twice at 15 and 45 dap
9. Application of *Select* herbicide once at 15 dap (100 mls/15 litres)
10. Application of *Select* twice at 15 and 30 dap (100 mls/15 litres)

The trials were conducted using an open-pollinated commercial sunflower variety (*Sunfola)* during the three seasons. The crop was planted at 75x30 cm and thinned to 1 plant per hole. Plots measured 4.5 x 5 m and the treatments were arranged as a RCBD replicated 4 times. Dates of various activities are summarized in the Table below.

Year	**Planting date**	**Weeding/herbicide application dates**			**Harvest date**
		1st	**2nd**	**3rd**	
2010	2nd June	17th June	1st July	15th July	1st August
2011	14th April	29th April	13th May	27th May	12th June
2012	31st July	21st August	4th September	17th September	3rd October

Numbers of weed species and their counts were taken before and one week after treatment applications. Measurements were also taken regularly on plant height, stem diameter and leaf area index (LAI). LAI was estimated by measuring lengths and widths of all active leaves from 4 plants in every plot at any sampling time and computed as described by Michael P. Bange *et al*. (2000). Head diameters were also measured, and at full maturity sunflower was harvested from the inner middle rows, leaving one row on either side of every plot. The crop was threshed, dried, winnowed, and yields per hectare calculated. During the three years of the study, sunflower was bought at an average price of Uganda Shillings 800=/kg and this was the price used to calculate incomes.

Weeding and herbicide application costs

Weeding costs around NaSARRI during the three years was based on the prevailing labour costs by then. Farmers charged on average, Uganda Shillings 3,000= for a space of 10 x 15 strides. At normal walking space, a stride is equivalent to 0.8 m and this transforms to 96 m^2 for Sh. 3,000= making a weeding cost of 312,500=/ha. For the herbicide, 100 mls sprayed 4 plots of 4.5 x 5 m (equivalent to 90 $m^{2)}$, making application rate of 11 litres/ha. The cost of spraying the herbicide was Uganda Shillings 500= per tank load (55,500=/ha). In total it cost Uganda Shillings 297,500=/ha for the cost of herbicide application according to this estimation.

Results and Discussion

Results obtained for the three seasons were very similar so the three year means for the different parameters are used in this paper. Data on LAI, lodging and stem diameter were not significantly affected by the weed control treatments studied so are excluded from the results.

Grass weed counts

At first sampling, grass weed counts were not significantly different across treatments (Table 1 and Figure 1). This was normal since no treatment had been imposed by this time and also indicates that sampling was started from a leveled ground.

During second sampling there was a significant reduction in number of weeds from treatments that had received the first weeding or herbicide applications at 15 dap. At this time there was no significant difference between hand weeded and herbicide treated plots. The herbicide (*Select)* significantly reduced counts of grass weeds compared to those treatments that were not yet weeded by this time, and the controls.

Data from third and fourth sampling showed effectiveness of the different weed management interventions which had already been imposed, as compared to the controls. However, there were no significant differences between treatments implemented at 15 and 30 dap. Even if a treatment (hand weeding or herbicide application) had not been imposed at 30 dap, the previous intervention at 15 dap still had full control of the grass weeds. Plots that were not yet weeded by this time had significantly higher counts of grass weeds.

Fifth sampling was the best time to see the full contrast. At this time grass weed counts from all other treatments were significantly lower than the non-weeded controls, while they were not significantly different amongst themselves. Also at this time weed re-growth from plots with treatments imposed at 15 dap was already high so that counts were similar and close to those from the controls.

Broad leafed weed counts

Data on broad leafed weed counts during the five sampling periods are presented in Table 2 and Figure 2. Weed dynamics during the different sampling periods and as affected by the different treatments are similar to what is presented under grass weeds. The main difference is that there were generally fewer broad leafed weeds compared to grass weeds at any sampling time. The herbicide had insignificant effects on broad leafed weeds compared to its effect on grass weeds.

Sunflower plant heights

Weeding sunflower once starting at 15 dap and twice at 15 and 30 dap significantly increased plant heights compared to the non weeded controls (Table 3). Other weeding treatments also increased heights but differences from the controls were not significant. Early application of *Select* to sunflower plots at 15 dap suppressed vertical growth so that plants from such plots were similar in height to the non weeded controls. Kowthar, *et al* (2013) reported varied effects of *Butralin, Fluazifop-P-butyl* and *Tribenuron-methyl* herbicide on sunflower plant heights, number of leaves and leaf area per plant of two sunflower varieties. *Butralin* reduced crop growth relative to control, while *Fluazifop-P-butyl* and *Tribenuron-methyl* increased these growth parameters to high significant values compared to the corresponding controls.

Sunflower head diameters

The largest sunflower heads were those form plots whose weeding started at 15 dap, whether once twice or thrice (Table 3). These heads were significantly larger than those from the non-weeded controls or those to which *Select* was applied. At all weed sampling dates, these treatments effectively kept numbers of both grasses and broad leafed weed species much lower than from the un weeded controls (Figures 1 and 2). This reduced weed competition against the crop and contributed to good growth, hence large heads. This observation supports the findings of Brighenti, *et al* 2004, who reported 21 to 30 days after emergence as the critical period of weed interference in sunflower.

Yields, incomes and margins

All hand weeding treatments significantly out yielded the non-weeded control plots and led to yield increases ranging from 10-60 % above the controls (Table 3). Hand weeding treatments did not significantly differ from each other and from those under herbicide application, which in turn did not significantly differ from the non-weeded control plots. All the four treatments whose weeding started at 15 dap were also the top four in respect of actual yields, yield increase above the control and incomes (Table 3 and 4). The most important factor among these four treatments was start time because any additional weeding whether at 30 or 45 dap or both never significantly increased yields. Starting to weed at 30 or 45 dap did not significantly reduce yields compared to start at 15 dap but significantly increased yields compared to the non weeded controls. Repeated weeding in sunflower twice or thrice added no benefits in terms of yields and incomes. Rather they increased the costs of weed control and reduced the margins which farmers would get. Unless for other reasons such as seed bed preparation for a subsequent crop, results from this study discourage repeated weeding of sunflower.

Conclusion

The data from this study emphasize that sunflower must be weeded, and weeding should start at, or around 15 dap but not exceed 45 dap. The earlier one starts, the better the

performance and more delays lead to reductions in yields. To maximize incomes and weeding margins, weeding should be done once.

The herbicide (*Select)* significantly reduced counts of grass weeds but had insignificant effects on broad leafed weeds. Yields, incomes and costs associated with its use whether once or twice do not justify its recommendation for sole use on sunflower in Uganda. However, where the problem is mainly grass weed species, the herbicide may be used with supplementary weeding. This needs further investigations.

Acknowledgements

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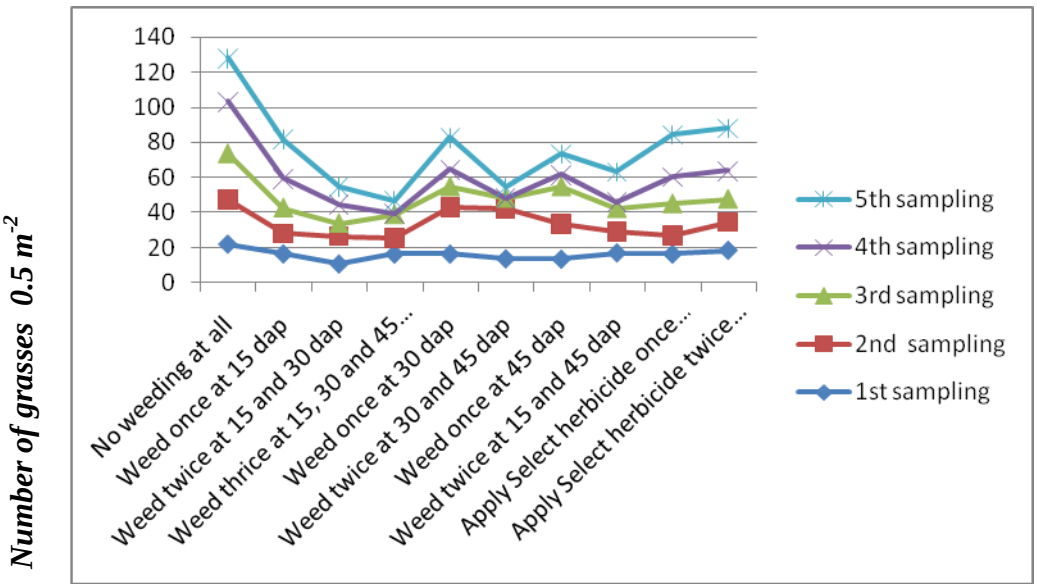
Table 1: Effects of different weed management options in sunflower on counts of grass weeds at NaSARRI

Treatment	Sampling sequence				
	1st	2nd	3rd	4th	5th
No weeding at all	22.0	25.6	25.9	29.8	24.8
Hand weed once (15 dap)	16.4	11.8	14.4	16.8	22.2
Hand weed twice (15 & 30 dap)	10.6	16.0	7.2	10.8	10.1
Hand weed thrice (15, 30 & 45 dap)	16.3	9.2	13.4	0.4	7.1
Hand weed once (30 dap)	16.3	26.8	11.6	9.8	18.1
Hand weed twice (30 & 45 dap)	13.6	28.6	6.0	0.0	6.2
Hand weed once (45 dap)	13.4	20.2	21.1	6.8	11.8
Hand weed twice (15 & 45 dap)	17.0	12.1	13.1	3.9	16.9
Apply *Select* once (15 dap)	16.3	10.8	17.9	15.4	24.0
Apply *Select* twice (15 & 30 dap)	18.5	16.2	12.9	16.1	24.4
Mean	**16.0**	**17.7**	**14.4**	**10.9**	**16.6**
Lsd	11.6	11.7	12.1	12.4	9.9
Cv (%)	*49.8*	*45.3*	*57.9*	*78.4*	*41.2*

Figure 1: Counts of grass weeds 0.5m^{-2} at different sampling dates and as affected by weed management practices at NaSARRI



Number of grasses 0.5 m^{-2}

Treatment

Table 2: Effects of different weed management options in sunflower on counts of broad leafed weed species at NaSARRI

Treatment	Sampling sequence				
	1st	2nd	3rd	4th	5th
No weeding at all	6.3	5.9	6.4	8.0	9.1
Hand weed once (15 dap)	2.9	4.3	4.3	5.4	6.9
Hand weed twice (15 & 30 dap)	3.9	2.8	2.1	1.8	2.4
Hand weed thrice (15, 30 & 45 dap)	2.9	2.9	2.6	0.1	3.9
Hand weed once (30 dap)	2.9	5.5	2.5	1.4	3.0
Hand weed twice (30 & 45 dap)	2.6	6.4	2.3	0.0	5.3
Hand weed once (45 dap)	6.1	7.1	4.9	0.5	3.4
Hand weed twice (15 & 45 dap)	3.1	1.1	4.0	0.5	4.4
Apply *Select* once (15 dap)	4.0	6.9	6.2	6.9	6.4
Apply *Select* twice (15 & 30 dap)	4.9	4.8	5.9	7.5	7.6
Mean	**4.0**	**4.8**	**4.1**	**3.2**	**5.2**
Lsd	2.3	2.9	3.3	2.7	3.4
Cv (%)	*41.0*	*42.9*	*55.4*	*58.3*	*44.4*

Figure 2: Counts of broad leafed weeds 0.5m^{-2} at different sampling dates and as affected by weed management practices at NaSARRI

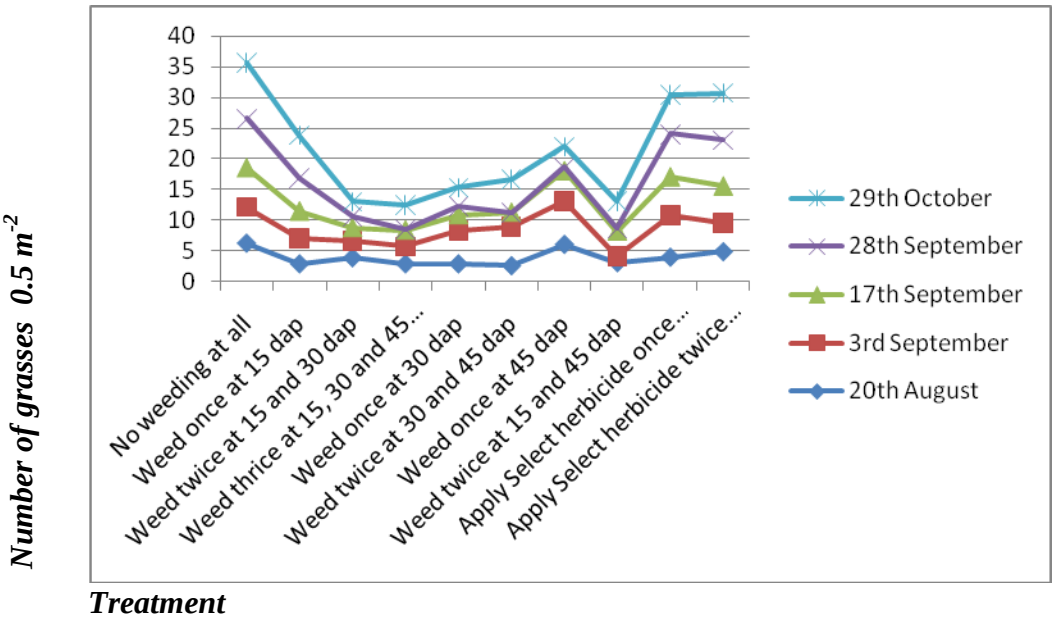


Table 3: Effects of different weed management options on mean sunflower heights, head diameters and yields at NaSARRI

Weed management Treatment	**Height (cm)**	**Head diameter (cm)**	**Yields (kg/ha)**	**% yield increase above the control**
No weeding at all	157.9	12.3	926.9	--
Hand weed once (15 dap)	171.4	16.5	1472.1	58.8
Hand weed twice (15 & 30 dap)	171.2	16.1	1445.5	55.9
Hand weed thrice (15, 30 & 45 dap)	165.5	16.7	1516.7	63.6
Hand weed once (30 dap)	165.2	15.1	1324.7	42.9
Hand weed twice (30 & 45 dap)	166.0	15.3	1321.4	42.5
Hand weed once (45 dap)	161.5	14.3	1301.9	40.4
Hand weed twice (15 & 45 dap)	169.8	17.9	1445.7	55.9
Apply *Select* once (15 dap)	152.9	13.9	1028.7	10.9
Apply *Select* twice (15 & 30 dap)	163.4	13.1	1025.4	10.6
Mean	**164.5**	**15.1**	**1280.9**	**---**
Lsd	15.3	3.1	258.8	---
Cv (%)	*5.4*	*12.2*	*11.8*	---

Table 4: Effects of different weed management options on mean sunflower yields, incomes and weeding margins (Uganda Shillings) at NaSARRI

Weed management Treatment	**(UGX/ha 000')**		
	Incomes	**Weed control cost**	**Weeding margin**
No weeding at all	742.52	0	742.52
Hand weed once (15 dap)	1,177.68	312.5	865.18
Hand weed twice (15 & 30 dap)	1,156.4	625.0	531.4
Hand weed thrice (15, 30 & 45 dap)	1,213.36	937.5	275.86
Hand weed once (30 dap)	1,059.76	312.5	747.26
Hand weed twice (30 & 45 dap)	1,057.12	625.0	432.12
Hand weed once (45 dap)	1,041.52	312.5	729.02
Hand weed twice (15 & 45 dap)	1,156.56	625.0	531.56
Apply *Select* once (15 dap)	822.96	297.5	525.46
Apply *Select* twice (15 & 30 dap)	820.32	595.0	225.32

Table 5: Rankings of the of different weed management options on sunflower at NaSARRI

Weed management Treatment	**Rank by Yield**	**Rank by Income**	**Rank by Margin**
No weeding at all	10	10	3
Hand weed once (15 dap)	2	2	1
Hand weed twice (15 & 30 dap)	4	4	6
Hand weed thrice (15, 30 & 45 dap)	1	1	9
Hand weed once (30 dap)	5	5	2
Hand weed twice (30 & 45 dap)	6	6	8
Hand weed once (45 dap)	7	7	4
Hand weed twice (15 & 45 dap)	3	3	5
Apply *Select* once (15 dap)	8	8	7
Apply *Select* twice (15 & 30 dap)	9	9	10

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