Herbicidal efficacy and selectivity of goal in potato (*Solanum tuberosum* L.) in the Northern State, Sudan

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ABSTRACT

Experiments were conducted at Elsaggai and Merowe, Northern State, Sudan, during the period 2007 to 2009 to assess the damage inflicted by weeds on potato and determine herbicidal efficacy and selectivity of the herbicide Goal (oxyfluorfen) in potato in the Northern State. Unrestricted weed growth reduced potato total and marketable yields by 50% - 84% and 54% - 97%, respectively. Goal at all rates and times of application reduced weed air-dry weight by 26% - 97%. It resulted in excellent early and late season control of grassy weeds. However, *Cynodon dactylon* (L.) Pers and *Cyperus rotundus* L. were not affected. Goal at all rates applied 7 and 14 days after planting (DAP) effected excellent (83% to 98%) and moderate (48% to 67%) late season control of broad-leaved weeds at Elsaggai and Merowe. Goal increased total and marketable tuber yields by 14% - 100% and 40% - 200%, in both locations respectively, over the unweeded control. The herbicide at 0.3 kg a.i/ha applied 7 DAP resulted in excellent (96% - 99%) and persistent control of annual grassy weeds and gave adequate (66% to 100%) control of broad-leaved weeds. It increased total and marketable tuber yields by 59% to 100% and 82% to 200%, respectively, over the control and is safely recommended for weed management in potato in the Northern State.

INTRODUCTION

Potato production is increasing annually in the Northern State. Farmers in the State seek to introduce new crops to improve their income . Traditional crops do not satisfy their needs. Weeds are the major problems to the crop. Potato competes poorly with weeds because of its slow growth in the initial emergence phase. The yield reduction in potato due to weeds is estimated as 10% - 80% (Channappagoudar *et al.*, 2007).

The critical period for weed control in potatoes is about 4 to 6 weeks after planting (Thakral, *et al.*, 1989). Hand weeding is expensive and laborers are scarce. Herbicides can reduce the number of cultivations required and enhance weed control (Chitsaz and Nelson, 1983; Nelson and Giles, 1989). Pre-emergence application of Sencor (metribuzin) at 0.75 kg ai/ha resulted in tuber yield comparable to the weed-free check (Channappagoudar, *et al*., 2007). Pre-emergence application of Igran 500 FW (terbutryne) and Stomp 330 E. (pendimethalin) revealed that Igran was more efficient in controlling the potential weeds of potato and increasing tuber yield than Stomp (Halimie, *et al.*, 1995). Pre-emergence application of Sencor controlled weeds and increased potato yield significantly and was found to be the least expensive herbicide compared to other weed control measures (Hamidullah, *et al.*, 2004). Pre-emergence application of Sencor particularly at higher dose (0.4 kg/ha) proved more effective in controlling weeds and increasing tuber yields (Ahuja, et al., 1999). Sencor was the best herbicide for the control of broad leaved weeds and many grasses and when coupled with supportive hand-weeding, it gave the best potato yield (Mohamed and Nour, 1986). The objective of this investigation was to determine the efficacy and selectivity of the herbicide Goal for weed control in potato.

MATERIALS AND METHODS

Experiments were conducted at Elsaggai Islands, Merowe locality in 2007/08 and 2008/09 seasons and at Merowe Northern State, Sudan in 2008/09 planting season, respectively. The objective was to evaluate

the herbicidal efficacy of Goal as influenced by rate and time of application on weed control in potato.

The experimental area was ploughed, harrowed, leveled and made into 70 cm ridges. The plot size was 4 × 3.6 m. Seed potato tubers, variety Alfa, were cut longitudinally into two halves with a sharp disinfected knife. One half of tuber was planted per hole immediately after cutting at 20 cm spacing during November. Super-phosphate (P_2O_5) was applied at the rate of 95 kg/ha immediately after planting. Irrigation interval was 12 days. Two sprays with Folimat were made in January to control aphids.

Goal was applied at the rates of 0.24, 0.30 and 0.36 kg a.i/ha as aqueous solution by a knapsack sprayer at a volume of 357 l/ha. The herbicide was sprayed either immediately after planting, 7 days after planting (DAP) or 14 DAP. Treatments were arranged in a randomized complete block design with 4 replicates. Weeded and unweeded plots were used as controls. The weeded plots received 4 hand-weedings starting 2 weeks after planting with 15 days interval. Nitrogen was applied at the rate of 86 kg/ha, as urea, one month from sowing.

Total and individual weed species in 1.0 m² were counted at 4 and 8 weeks after planting (WAP). The crop was harvested in the second and third weeks of March. The harvested area was 3.5× 3.1 m. At harvest, weed air-dry weight was recorded. Data taken consisted of total and marketable tuber yields.

Residue analysis was carried out for the higher dose which was 1.5 l/ha (360 g a.i./ha). A sample of 50 g from treated and untreated potato tubers was extracted using a standard method. Then the extracts were concentrated to dryness and the residues were dissolved into acetone (0.5 ml) and kept for analysis. Analysis was carried out using thin-layer chromatography (TLC) provided with plastic ready-made silica gel GF_{254} coated plates with a thickness of 0.25 mm (Merek). After spotting of Goal standard and samples, the plates were developed in a system of hexane/acetone (4:1), and visualized under short wave ultra violet lamp (254 nm).

Data were analyzed using the analysis of variance procedure and means were separated using Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

At Elsaggai, in 2007/08 season, the dominant weeds were *Cyperus rotundus* L., *Chenopodium album* L., *Cynodon dactylon* (L.) Pers, *Amaranthus* spp. and *Sinapis arvensis* L. (55, 13, 12, 8 and 7% of the total weed flora, respectively). Goal at all rates and times of application effected excellent early (4 WAP) and late (8 WAP) season control (88% to 100%) of broad-leaved weeds (Table 1). *Cyperus rotundus* and *C. dactylon* were, however, not affected (tolerated the herbicide); a similar finding was reported by Hamdoun and Babiker (1978). The herbicide Goal applied at all rates and times of application reduced weed air-dry weight by 26% to 69% (Table 1).

At Elsaggai, in 2008/09 season, the total weeds were 200 plants/m². The dominant weeds were *Sorghum arundinaceum* (Del.) Stapf., *Echinochloa colona* (L.) Link. and *Eruca sativa* L. (73%, 17% and 5% of the total weed flora, respectively). Goal at all rates and times of application with few exceptions effected excellent (90% to 99%) early and late season control of grassy weeds. The herbicide at the low and medium rates applied 7 DAP gave moderate (58% and 68%, respectively) early season control of broad-leaved weeds.

Goal at all rates (applied at 7 and 14 DAP) resulted in excellent (83% to 95%) and lasting control of broad-leaved weeds. When it was applied at 0.3 kg a.i /ha and sprayed 7 DAP, it effected excellent (96% and 99%) and persistent control of grasses and resulted in adequate (68% and 91%) control of broad-leaved weeds.

Table 1: Effects of Goal on weed control in potato at Elsaggai (season 2007/08).

Treatment	Rate (kg a.i ha^{-1})	Weed control (%)				Weed air dry weight (g m^{-2})
		4 WAP		8 WAP		
		G	BL	G	BL	
Goal at planting	0.24	0	88	0	94	405b
	0.30	12	92	0	90	409b
	0.36	0	96	0	90	369b
Goal 7 DAP	0.24	0	92	0	97	350bc
	0.30	6	100	0	98	288cd
	0.36	0	100	0	98	250d
Goal 14 DAP	0.24	17	100	0	95	253d
	0.30	21	92	0	97	250d
	0.36	9	100	0	92	169e
HW control	-	100	100	100	100	0f
Un W control	-	0	0	0	0	550a
S.E.±	-	-	-	-	-	24.9
Sig. level	-	-	-	-	-	***
C.V.%						16.6

HW = Hand weeded, Un W = Unweeded, WAP = Weeks after planting, DAP = Days after planting, G = Grasses, BL = Broadleaved.

Means in a column followed by the same letter (s) are not significantly different at P = 0.05 according to Duncan's Multiple Range Test.

*** Significant at P = 0.001.

The herbicide at all rates and times of application reduced weed air-dry weight by 33% to 96% (Table 2). Unrestricted weed growth reduced both the total and the marketable tuber yields by 50% - 66% and 54% -59% respectively. The herbicide at all rates and times of application, with a single exception, increased the total and the marketable tuber yields by 14% - 185% and 40% - 142%, respectively, over the unweeded control (Table 3).

Table 2. Effects of Goal on weed control in potato at Elsaggai (season 2008/09).

Treatments	Rate (kg a.i ha^{-1})	% weed control				Weeds air dry weight (g m^{-2})
		4WAP		8 WAP		
		G	BL	G	BL	
Goal at planting	0.24	93	0.0	95	26	600c
	0.30	93	44	98	52	378e
	0.36	94	12	98	68	456d
Goal 7 DAP	0.24	98	58	99	95	493d
	0.30	96	68	99	91	44g
	0.36	90	44	96	90	265f
Goal 14 DAP	0.24	77	54	94	83	309f
	0.30	65	41	91	95	673b
	0.36	73 100	44	93	95	493d
Hand weeded	-	0	100	100	100	0g
control	-	-	0	0	0	1000a
Unweeded control	-	-	-	-	-	22.5
S.E. ±	-	-	-	-	-	***
Sig. level	-		-	-	-	10
C.V.%						

WAP = Weeks after planting, DAP = Days after planting, G = Grasses, BL = Broad leaved.

Means in a column followed by the same letter (s) are not significantly different at P = 0.05, according to Duncan's Multiple Range Test.

*** Significant at P = 0.001.

At Merowe, in 2008/09 season, the total weeds were 93 plants/m^2. The dominant weeds were *S. arundinaceum, S. arvensis* and *E. sativa* (80%, 8% and 8% of the total weed flora, respectively). Goal at all rates and times of application resulted in excellent (90% to 99%) and lasting control of grassy weeds. It also gave an excellent (76% to 98%) early control of broad-leaved weeds. Goal at all rates when applied 7 and 14 DAP resulted in a satisfactory (48% to 67%) late season control of broad-leaved weeds. The herbicide Goal at all rates and times of application reduced weed air-dry weight by 53% to 97%

(Table 3). Unrestricted weed growth reduced total and marketable tuber yields by 84% and 97%, respectively. Application of Goal at all rates and times of application increased total and marketable tuber yields by 67% to 100% and 80% to 200%, respectively, over the weedy control (Table 4).

Table 3. **Effects of Goal on weed control in potato (Merowe research farm season 2008/09).**

Rate Treatment	(kg a.i ha^{-1})	% weed control				Weeds air-dry weight (g m^{-2})
		4WAP		8WAP		
		G	BL	G	BL	
Goal at planting	0.24	95	40	95	0	300b
	0.30	95	76	99	2	312b
	0.36	98	81	98	31	281bc
Goal 7 DAP	0.24	99	92	98	48	20f
	0.30	99	97	99	66	248c
	0.36	99	98	98	67	146d
Goal 14 DAP	0.24	94	95	94	58	269bc
	0.30	96	96	96	67	88e
	0.36	95	95	90	63	45ef
Hand weeded	-	100	100	100	100	0f
control	-	0	0	0	0	665a
Unweeded control	-	-	-	-	-	16.5
S.E. ±	-	-	-	-	-	***
Sig. level	-	-	-	-	-	15.3
C.V.%						

WAP = Weeks after planting, DAP = Days after planting, G = Grasses, BL = Broad leaved.

Means in a column followed by the same letter (s) are not significantly different at P= 0.05, according to Duncan's Multiple Range Test.

*** Significant at P = 0.001.

The low yield in season 2008/09 compared to season 2007/08 may be attributed to the high temperature in season 2008/09 during main crop growth period (January and February). Robert *et al*., (1990) reported that high temperature reduced potato production. The variation in yield between sites in season 2008/09 may probably be due to soil characteristics. Stalham *et al*., (2007) reported that soil compaction reduced potato tuber yield.

Table 4. Effects of herbicide treatments on potato tuber yield in the Northern State.

Treatment	Rate	T T Y	M T Y	T T Y	M T Y	T T Y	M T Y
	(kg a.i. ha^{-1})			(ton ha^{-1})			
		2007/08		2008/09 A		2008/09 B	
Goal at planting	0.24	10.3d	7.9f	3.8e	3.0d	1.0 d	0.3g
	0.30	14.01b	11.9cd	6.1c	4.5b	1.9 c	0.93e
	0.36	12.3c	10.9de	4.6d	3.4c	1.3 d	0.41f
Goal 7 DAP	0.24	13.8b	11.4de	6.0c	4.3b	3.5 a	2.0 b
	0.30	14.3b	13.3b	7.4a	5.2a	3.8 a	2.3a
	0.36	12.3c	10.4e	7.1b	4.5b	2.9 b	1.6c
Goal 14 DAP	0.24	14.2b	12.6bc	6.9b	4.4b	2.7 b	1.4d
	0.30	12.3c	11.03de	4.4d	3.3c	2.9 b	1.3d
	0.36	14.5b	13.2b	5.8c	4.3b	3.4 a	1.9b
HW control	-	18.0a	15.8a	7.6a	5.2a	3.7 a	2.4a
UW control	-	9.0e	7.3f	2.6f	2.15e	0.6 e	0.07h
S.E. ±	-	0.23	0.34	0.09	0.08	0.123	0.035
Sig. level	-	***	***	***	***	***	***
C.V.%	-	3.6	6.1	3.17	4.13	9.82	5.3

T T Y = Total tuber yield**,** M T Y = Marketable tuber yield**,** Marketable = 35 – 65 mm in diameter, DAP = Days after planting**.**

Means in columns followed by the same letter (s) are not significantly different at P = 0.05, according to Duncan's Multiple Range Test**.**

*** Significant at P = 0.001.

HW = Hand weeded, UW = Unweeded, A = Elsaggi site and B = Merowe site.

Results of the residue analysis showed that neither the herbicide nor its metabolites were detected in the treated samples of potato which indicates that they were below the detection limit(Table 5). The maximum residue limit (MRL) of Goal in potato is 1 μg/g. Therefore, the use of Goal 240 EC on potato is safe when used at the recommended dose.

Table 5. Residues of Goal in potato.

Sample no.	Sample dosage rate	Residues (ppm)	Rf value
1	o.63 L/fed (151 g a.i.)	ND	-
2	Untreated control	ND	-
3	Reference standard of oxyflourfen	0.5	0.45

ND = not detected (below the minimum detectable limit).

In conclusion application of Goal at 0.3 kg a.i./ha 7 DAP resulted in excellent weed control, increased total and marketable yields, and resulted in no residues in treated tuber samples.

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فعالية واختيارية مبيد الحشائش قول في محصول البطاطس (*Solanum tuberosum* L.) بشمال السودان

كمال عبد الله محمد بدري[1] ، روضة يعقوب الحبيب[1] ، مهدى عبد الرحمن احمد[1] وإقبال عبد القادر عبد اللطيف[2]

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الخلاصة

أجريت هذه التجربة بمنطقتي السقاى ومروى بشمال السودان في الفترة من 2007 وحتى 2009م لمعرفة الضرر الذي تحدثه الحشائش لمحصول البطاطس وتحديد فعالية واختيارية مبيد القول (اوكسيفلورفن) على مكافحة الحشائش ومحصول البطاطس بالولاية الشمالية. أدى وجود الحشائش إلى خفض معنوي للإنتاج الكلى والتجاري للدرنات بنسبة 50% - 84% و54% - 97% على التوالي . خفض القول بكل جرعاته وزمن إضافتها الوزن الجاف للحشائش بنسبة 26 - 97% . كانت مكافحة مبيد الحشائش بكل جرعاته وزمن إضافتها مع قليل من الاستثناء ممتازة (90- 99%) للحشائش رفيعة الأوراق. لم تتأثر حشيشتى النجيلة والسعدة بالمبيد قول بكل جرعاته المضافة بعد 7 و 14 يوم من الزراعة ونتج عنه مكافحة ممتازة 83 – 98% ومتوسطة 48 – 67% للحشائش عريضة الأوراق في كل من السقاى ومروى على التوالى. زاد مبيد الحشائش بكل جرعاته وزمن إضافتها باستثناء واحد الإنتاج الكلى والتجاري بمعدل 14 –100% و40 - 200% على التوالي زيادة فوق الشاهد. قول بمعدل 0.3 كجم مادة فعالة للهكتار يرش بعد سبعة أيام من الزراعة أدى إلى مكافحة ممتازة (96 - 99%) ومستمرة للحشائش الحولية رفيعة الأوراق ومكافحة كافية (66 - 100%) للحشائش عريضة الأوراق وكانت الزيادة بأمان في الإنتاج الكلى والتجاري لدرنات البطاطس بمعدل 59 –100 % و 82 –200% على التوالي زيادة فوق الشاهد.