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(RESEARCH ARTICLE)

# Orange-fleshed potato cultivars' responsiveness to herbicides and weed species interruption in Njala, Moyamba District, Southern Sierra Leone.

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## Abstract

The 2019 and 2020 field experiments were established to evaluate pre-emergence herbicides and weed interruption on orange-fleshed potato cultivars' productivity. The experiment was executed at the Crop Protection Department trial site, Njala University Campus using a strip-plot design in three replications. Results indicated that Button (*Diodia scandens*) and Rushfoil (*Croton hirtus*) broadleaved weed species arose as the utmost predominant weed types that showed 58.52% and 25.68% relative density, respectively. Notwithstanding, Mathuthu orange-fleshed cultivar exhibited maximum weed competitive ability (5.14). The application of Prometraine (5 L $ha^{-1}$) and hand weeding at 4 weeks after planting, revealed maximum herbicide efficiency index (20.65), yield (7.04 t $ha^{-1}$), net field benefit (SLL 2,564.64), total variable cost (SLL 2,300.00) as well as profitability (113.48%). Therefore, application of Prometraine (5 L $ha^{-1}$) and supplementary hand weeding at 4 weeks after planting may be acknowledged to farmers as an efficient and cost-effective weed management strategy in orange-fleshed potato cultivars' productivity.

**Keywords:** Cost-Effective; Orange-Fleshed; Cultivars; Herbicides; Weed Interruption; Weed Species

## *1.* Introduction

Worldwide, the production of sweet potatoes initiated from Southern and Central America with a production range of 100-300 million metric tonnes, being cultivated on 19 million hectares [1]. Also, an estimation of 28,446 metric tonnes of sweet potato cultivated in the 11,764-ha area has been reported by [2]. According to [3], industries that produce ethanol, dyes, fabrics, and cosmetics utilizes the crop as raw material. In Sierra Leone, the orange-fleshed cultivars are generally consumed by needy families, because it possesses the enormous nutritive value of beta-carotene.

Apart from the diverse utilizations and benefits that sweet potato obtained in Sierra Leone, its husbandry is comparatively decreased as a result of weed intrusion, deficient weed control techniques, as well as insufficient better-quality cultivars. Of these, weed species pervasiveness emphasized may cause 70% yield reduction [4].

Therefore, most orange-fleshed potato farmers managed weeds via hand pulling or hoeing in Sierra Leone, even though it has been long-established as inadequate and inconvenient. Conversely, scientists have recommended herbicides as an effective weed control method, but as a result of dissimilarities in the heritability amidst potato cultivars and selection of herbicides, further studies are needed. Thus, since cost-effective weed management strategies in orange-fleshed potato cultivars husbandry is a prerequisite, this research was performed to evaluate the response of orange-fleshed potato cultivars to pre-emergence herbicides, weed interruption and productivity.

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## 2. Materials and Methods

The research was conducted in the Crop Protection Department trial site, Njala University (N 08$^0$ 06.577', W 012$^0$ 03.858' and elevation 51m). The field trials on orange-fleshed potato (Improved) and local cultivars were established in the years of 2019 and 2020. Required materials used for the establishment of these trials were three released cultivars of orange-fleshed plus indigenous cultivar. A compound fertilizer NPK 15:15:15 and herbicides were acquired from agrochemical stores. Whereas locally manufactured farm implements like hoes, shovels, pickaxes, axes and machetes were used for land preparation. Table 1 shows the initial physio-chemical properties of the experimental soil.

**Table 1** Physio-chemical properties of the soil at the experimental sites prior to trial establishment during 2019 and 2020 main cropping seasons

| **Soil properties** | **Cropping year** | |
|---|---|---|
| | 2019 | 2020 |
| Soil chemical characteristics | | |
| Soil pH ($H_20$) | 3.91 | 3.9 |
| Organic matter (g $kg^{-1}$) | 1.85 | 1.4 |
| Total Nitrogen (g $kg^{-1}$) | | |
| Available phosphorus (mg $kg^{-1}$) | 89 | 76 |
| Exchangeable cations | | |
| potassium (Cmol/ $kg^{-1}$) | 0.14 | 0.065 |
| Particle size distribution (g $kg^{-1}$) | | |
| Sand | 75 | 74 |
| Silt | 10 | 6 |
| Clay | 15 | 20 |
| Soil texture | Sandy clay loam | |

### 2.1. Trial Design and Treatments

The experiments were arranged in a factorial system using a strip-plot design in three replications. Three improved orange-fleshed (Mathuthu, Chipika, and Kaphulira) and one native farmers' cultivar (Kabia) were planted in the main plots; while the sub-plots contained the following weed control methods (Hand weeding at 4 and 8 weeks after planting (WAP), weedy check, Quizalopane 5L $ha^{-1}$ plus hand weeding 4 WAP, Prometraine 5L $ha^{-1}$ and hand weeding 4 WAP and Gariane 5L $ha^{-1}$ plus hand weeding 4 WAP). The plantings were done in plots sizes of 5 m x 5 m, with a spacing of 1m x 1m.

### 2.2. Agronomic Procedures

All pre-emergence herbicides (Quizalopane 100 EC, Prometraine 500 SC, and Gariane) were applied a day after transplanting at their recommended rates (5 L $ha^{-1}$), followed by one supplementary hand weeding at 4 WAP, respectively. Thereafter, application of a compound fertilizer (NPK 15:15:15) at a rate of 200kg $ha^{-1}$ was executed two weeks after transplanting. The recommended cultural practices were carried out during the entire course of study.

### 2.3. Weed Species Composition

The compositions of weed species were determined by indiscriminately flinging a 0.5 $m^2$ quadrat per treatment. Thereafter, weed species that are confined within the 0.25 $m^2$ quadrat were harvested, quantified, and documented based on their innumerable flora, lifespan and morphology. The quantified samples of weed species were air-dried for about two weeks, parceled into brown envelops, oven dried at 65$^0$ C and dry weed weight (Weed biomass) determined by using a precision scale (Methler PE 6000). In addition, weed indices such as relative weed density (RWD), herbicide efficiency index (HEI), as well as weed competitive index (WCI) were calculated according to formulae established by [5] and [6].

Saleable and nonsalable yields were determined using a weighing balance (Methler PE 6000) and yields calculated according to the formula applied by [7].

### 2.4. Cost-effective Analysis

The cost-effective analysis obtained from both years' data was likewise computed as been reported by [8].

### 2.5. Statistics Analysis

Yield, weed composition and herbicides efficacy data were analysed using analysis of variance (ANOVA), and post hoc mean separation conducted using the Least Significant Difference (LSD) test at 0.05 (SAS version 9.4).

## 3. Results and Discussion

### 3.1. Weed Species Composition

The efficiency of herbicides coupled with one hand-weeding at 4 WAP revealed significant (P < 0.05) influence on diversity of weed flora compositions (Table 2). The present field research showed that eight diverse weed floras emerged from seven dissimilar families. Amidst these copious weed floras identified, 62.5% were broadleaved weeds, 25% grasses and 12.5% sedges. Nevertheless, 75% and 25% were recognized to be perennial and annual weed species, respectively. However, the *Diodia scandens* weed flora belonging to the Rubiaceae family showed maximum percentage of the relative weed density (58.52%) than all other weed species compositions acknowledged in 2019 and 2020 research. Rubiaceae family had 56.12% and 99.95% increase over Euphorbiaceae and Combretaceae families, respectively (Table 2). The results obtained from the diversity of weed floras and their compositions in sweet potato cultivars production are comparable to the confirmations made by [9] and [10] of different weed species in other crops.

**Table 2** Predominant weed floras and their relative densities during 2019 and 2020 main cropping seasons.

| Family | Species | Lifespan cycle | Growth habit | Relative weed density (%) |
|---|---|---|---|---|
| Combretaceae | *Combretum hereroense* | Perennial | Broadleaf | 0.03 |
| Cyperaceae | *Cyperus rotundus* | Perennial | Sedge | 1.28 |
| Euphorbiaceae | *Croton hirtus* | Annual | Broadleaf | 25.68 |
| Fabaceae | *Calopogonium mucunoides* | Perennial | Broadleaf | 0.44 |
| Poaceae | *Paicum maximum* | Perennial | Grass | 0.13 |
| | *Digitaria ciliaris* | Annual | Grass | 13.48 |
| Rubiaceae | *Diodia scandens* | Perennial | Broadleaf | 58.52 |
| Solanaceae | *Solanum dulcamara* | Perennial | Broadleaf | 0.44 |

### 3.2. Herbicide efficiency and weed competitive indexes

As indicated in Table 3, herbicides effectiveness had significant (P < 0.05) effects on the weed management strategies across both cropping seasons. Hence, the highest herbicide efficiency index (18.25 and 23.05) was significantly (P < 0.05) recorded using Prometraine 5 L $ha^{-1}$ plus one supplementary hand weeding at 4 WAP, respectively. Its herbicide efficiency index was 11.43% superior to that of Gariane 5 L $ha^{-1}$ plus one supplementary hand weeding at 4 WAP for both years. Likewise, [11] reported that isoproturon applied at 2 kg $ha^{-1}$ recorded maximum increase of herbicide efficiency index.

Moreover, with respect to sweet potato cultivars, significant (P < 0.05) differences were observed in weed competitive indices (Table 2). The Mathuthu (5.14) and Kaphulira (4.24) orange-fleshed potato cultivars revealed maximum disparity in weed competitive index, respectively. Whereas, the lowermost weed competitive index (1.27 and 1.59) was significantly (P < 0.05) reported by Chipika orange-fleshed cultivar. Similar results had been previously supported by [12] that crossbred cultivars contend exceedingly than inherited cultivars.

**Table 3** Influence of sweet potato cultivars and weed management strategies on herbicide efficiency and weed competitive indexes in 2019 and 2020 main cropping seasons.

| **Weed control practices** | **Herbicide efficiency index (HEI)** | | | **Weed competitive index (WCI)** | |
|---|---|---|---|---|---|
| | 2019 | 2020 | **Variety** | 2019 | 2020 |
| Prometraine 5 L $ha^{-1}$ + hand weeding 4 WAP | $18.25^{a}$ | $23.05^{a}$ | Kaphulira | $3.91^{ab}$ | $4.24^{a}$ |
| Quizalopane 5 L $ha^{-1}$ + hand weeding 4 WAP | $14.31^{a}$ | $18.03^{a}$ | Mathuthu | $5.14^{a}$ | $4.18^{a}$ |
| Gariane 5 L $ha^{-1}$ + hand weeding 4 WAP | $1.92^{b}$ | $1.89^{b}$ | Kabia | $2.71^{ab}$ | $2.65^{ab}$ |
| Hand weeding 4 and 8 WAP | - | - | Chipika | $1.27^{b}$ | $1.59^{b}$ |
| Weedy check | - | - | | | |
| Pr > F (5%) | 0.0387 | 0.0134 | | 0.1292 | 0.1179 |
| LSD (%) | 11.09 | 11.71 | | 2.94 | 2.22 |

Means with alike letters are not significantly dissimilar

### 3.3. Yield

There were significant ($P < 0.05$) differences amidst the yields of sweet potato cultivars (Table 4). For both research years, 5.86 t ha $^{-1}$ and 6.71 t $ha^{-1}$ were respectively yields of Kaphurila (Orange-fleshed cultivar) accompanied by Mathuthu (5.80 t $ha^{-1}$ and 4.88 t $ha^{-1}$). Whereas the local cultivar (Kabia) significantly ($P < 0.05$) yielded the lowest (1.61 t $ha^{-1}$ and 2.52 t $ha^{-1}$) of all cultivars. However, the average root yields of Kaphurila cultivar surpasses that of Kabia by 32.91% $ha^{-1}$. Similarly, the disparity in average tuber yields due to variances in crop genotypic build-up had been reported by [13].

With respect to weed control methods, the combination of the application of Prometraine 5 L $ha^{-1}$ plus one supplementary hand weeding at 4 WAP significantly ($P < 0.05$) recorded maximum yields of 6.54 t $ha^{-1}$ and 7.54 t $ha^{-1}$ in 2019 and 2020, respectively. This may be possibly attributed to the effectiveness of the herbicide, as had been previously testified by [14] and [15]. The pre-emergence application of Gariane 5 L $ha^{-1}$ plus one supplementary hand weeding at 4 WAP efficiently managed diverse weed species, irrespective of obtaining reduced yields (2.48 t $ha^{-1}$ and 1.05 t $ha^{-1}$). The present results affirmed the findings of [16], they testified that the application of post-emergence imazethapyr resulted in crop injury.

### 3.4. Cost-effectiveness

The cost-effectiveness $ha^{-1}$ was significantly pretentious by diverse weed management methods shown in Table 5. The prices of these pre-emergent herbicides Gariane, Prometraine and Quizalopane during the course of the experiment were SLL 180.00, SLL 150.00 and SLL 160.00 per litre. Furthermore, labour cost for land preparation including hand-weeding and harvesting per man-day was SLL 25.00 and required 40 and 20 man-days $ha^{-1}$, respectively. Nevertheless, the maximum gross field benefit (SLL 4,864.64 $ha^{-1}$), higher profitability (113.48%), but lower total variable cost (SLL 2,300.00 $ha^{-1}$) were attained in Prometraine 5 L $ha^{-1}$ plus one supplementary hand weeding at 4 WAP, respectively. The above explanations likewise go across cultivars and weed management methods, and it implies that for every SLL 100.00 spent for applying Prometraine at 5 L $ha^{-1}$ and supplemented with one hand weeding at 4 WAP, a farmer is feasible to make a profit margin of SLL 113.48 $ha^{-1}$ compared with the weedy check treatment. However, as a result of lowermost gross field benefit (SLL 3,703.76 $ha^{-1}$), maximum total variable cost (SLL 2,500.00 $ha^{-1}$) and minimum profitability (37.87%) realised in 2 hand weeding (4 and 8WAP), Prometraine and Quizalopane (5 L $ha^{-1}$, separately) plus one supplementary hand weeding at 4 WAP dominated, respectively.

Moreover, the 2 hand weeding (4 and 8 WAP) treatment obtained greater total variable cost of production (SLL 2,500.00 $ha^{-1}$) and diminished profitability of 37.87%. Whereas reduction in gross field benefit (SLL 808.47 $ha^{-1}$), total variable cost of production (SLL 400.00 $ha^{-1}$) and net field benefit (SLL 408.47 $ha^{-1}$) were achieved in weedy check treatment. Contrariwise, the application of pre-emergence Gariane 5 L $ha^{-1}$ plus one supplementary hand weeding at 4 WAP recorded higher phytotoxicity and unattractive net field benefit (SLL-1,230.38 $ha^{-1}$).

**Table 4** Impact of sweet potato cultivars and weed management strategies on yields of sweet potato in 2019 and 2020 main cropping seasons

| Treatment | Yield (t ha$^{-1}$) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **2019** | | | | | **2020** | | | | |
| | Chipika | **Kabia** | **Kaphulira** | **Mathuthu** | **Mean** | **Chipika** | **Kabia** | **Kaphulira** | **Mathuthu** | **Mean** |
| Gariane 5 L ha$^{-1}$ + hand weeding 4 WAP | 0.16 | 0.16 | 0.74 | 8.88 | 2.48 | 1.23 | 1.00 | 1.00 | 1.00 | 1.05 |
| Hand weeding 4 and 8 WAP | 4.66 | 1.56 | 7.71 | 5.53 | 4.86 | 5.66 | 2.56 | 8.71 | 6.53 | 5.86 |
| Prometraine 5 L ha$^{-1}$ + hand weeding 4 WAP | 5.34 | 3.06 | 12.18 | 5.60 | 6.54 | 6.32 | 4.06 | 13.18 | 6.60 | 7.54 |
| Quizalopane 5 L ha$^{-1}$ + hand weeding 4 WAP | 7.00 | 2.40 | 8.14 | 7.93 | 6.36 | 7.67 | 3.40 | 9.14 | 8.93 | 7.28 |
| Weedy check | 0.90 | 0.90 | 0.53 | 1.06 | 0.85 | 1.53 | 1.60 | 1.53 | 1.36 | 1.50 |
| Mean | 3.61 | 1.61 | 5.86 | 5.80 | | 4.48 | 2.52 | 6.71 | 4.88 | |
| SED: Variety (V) | 0.30 | | | | | 0.32 | | | | |
| SED: Weed control (W) | 0.34 | | | | | 0.35 | | | | |
| SED: V x W | 0.69 | | | | | 0.71 | | | | |

**Table 5** Cost-effective analysis of sweet potato cultivars and weed management strategies in 2019 and 2020 main cropping seasons

| Items | Gariane 5 L ha$^{-1}$ + hand weeding 4 WAP | Hand weeding 4 and 8 WAP | Prometraine 5 L ha$^{-1}$ + hand weeding 4 WAP | Quizalopane 5 L ha$^{-1}$ + hand weeding 4 WAP | Weedy check |
|---|---|---|---|---|---|
| Yield (t ha$^{-1}$) | 1.765 | 5.36 | 7.04 | 6.82 | 1.17 |
| Sweet potato root price per 100 kg (SLL) | 691.00 | 691.00 | 691.00 | 691.00 | 691.00 |
| Gross field benefits (SLL) | 1,219.62 | 3,703.76 | 4,864.64 | 4,712.62 | 808.47 |
| Labour cost for hand weeding (SLL) | 1,000.00 | 2,000.00 | 1,000.00 | 1,000.00 | - |
| Cost of herbicide (SLL) | 900.00 | - | 750.00 | 800.00 | - |
| Herbicide application cost (SLL) | 50.00 | - | 50.00 | 50.00 | - |
| Harvesting cost (SLL) | 500.00 | 500.00 | 500.00 | 500.00 | 400.00 |
| Total variable cost (SLL) | 2,450.00 | 2,500.00 | 2,300.00 | 2,350.00 | 400.00 |
| Net field benefit (SLL) | -1,230.38 | 1,203.76 | 2,564.64 | 2,362.62 | 408.47 |
| Profitability (%) | -79.94 | 37.87 | 113.48 | 100.21 | - |

## 4. Conclusions

In this study, it is concluded that, the composition of *Diodia scandens* flora comparatively increased by 56.12% and 99.95% over *Croton hirtus* and *Combretum hereeornse*, respectively. The combination of Prometraine 5L ha$^{-1}$ plus one supplementary hand weeding at 4 WAP had shown highest herbicide efficiency index, yield, gross field benefit, net field benefit and profitability across variety and year. Thus, safe, cheap plus excellent weed management strategy in sweet potato cultivation will be achieved under pre-emergence application of Prometraine 5L ha$^{-1}$ plus one supplementary hand weeding at 4 WAP.

## Compliance with ethical standards

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### *Disclosure of conflict of interest*

The authors have no conflict of interests relevant to this manuscript.

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