RESPONSE OF ONION (Allium cepa L.) TO PLANT POPULATION AND WEED CONTROL METHODS IN A CHICKEN WEED (Portulaca quadrifida L.) INFESTED FIELD IN SUDAN SAVANNA, NIGERIA

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ABSTRACT

Chicken weed is a significant weed in India and it occurs under onion cultivated field at Birnin Kebbi in the Sudan Savannah, Nigeria. On-farm experiment was conducted at Birnin Kebbi during the 2017/2018 and 2018/2019 dry season to evaluate the effect of plant population and weed control methods on the management of chicken weed (Portulaca quadrifida) alongside other weeds in onion field. The experiment consisted of three plant populations (500,000, 333,333 and 250,000 plants per hectare) and twelve weed control methods (Pendimethalin at 1.0 kg a.i. ha\(^{-1}\); + 1Hw; pendimethalin at 1.5 kg a.i. ha\(^{-1}\) + fluzifop-p-butyl at 2.0 kg a.i. ha\(^{-1}\); pendimethalin at 2.0 kg a.i. ha\(^{-1}\); butachlor at 2.0 kg a.i. ha\(^{-1}\) + 1Hw; butachlor at 2.8 kg a.i. ha\(^{-1}\) + oxyfluorfen at 1.0 kg a.i. ha\(^{-1}\); butachlor at 3.6 kg a.i. ha\(^{-1}\); fluzifop-p-butyl at 2.0 kg a.i. ha\(^{-1}\); oxyfluorfen at 1.0 kg a.i. ha\(^{-1}\) + 1Hw; hoe weeding at 3 (WAT); hoe weeding at 3 and 6 WAT; weed free and weedy check). The experiment was laid out in a randomized complete Block design replicated three times. Results showed that weed, growth and yield parameters were not significantly affected by plant population. Pendimethalin at 1.5 kg a.i. ha\(^{-1}\) + fluzifop-p-butyl at 2.0 kg a.i. ha\(^{-1}\) and weed free plots consistently recorded the lowest weed cover and highest weed control efficiency. Butachlor at 2.0 kg a.i. ha\(^{-1}\) + 1 Hw recorded the lowest crop injury score. Increase in plant height was observed when pendimethalin at 1.0 and 1.5 kg a.i. ha\(^{-1}\) + 1 Hw and fluzifop-p-butyl at 2.0 kg a.i. ha\(^{-1}\) respectively was applied, while application of pendimethalin at 2.0 kg a.i. ha\(^{-1}\) and butachlor at 2.0 kg a.i. ha\(^{-1}\) + 1 Hw recorded highest number of leaves and leaf area. Cured bulb and marketable bulb yield were greater with the use of pendimethalin and butachlor at 1.0 and 1.5 kg a.i. ha\(^{-1}\) + 1 Hw and the pooled data respectively. Application of pendimethalin and butachlor at the rate of 1.0 and 2.0 kg a.i. ha\(^{-1}\) followed by 1 Hw at 6 WAT respectively was therefore recommended for the control of chicken weed alongside other weed species in the ecology.

KEYWORDS: Chicken weed, weed control, plant population, weed density, weed control efficiency

INTRODUCTION

Chicken weed (Portulaca quadrifida L.) belongs to the family Portulacaceae (Nyffeler and Eggl, 2010). It originated from India and has been widely distributed in other temperate and tropical areas of the world (Lie et al., 2015 and Zhou, 2015). Gilbert and Phillips (2000) described P. quadrifida as having a mat-forming habit and prostrate stems which can root from the nodes. The flowers are said to open promptly at 10:00am, hence the English name ten O’clock plants (Grubben and Derton 2004), but is most preferably called Chicken weed (PROTA, 2014). Portulaca quadrifida is an annual weed that causes significant damage to a variety of crops. The genus Portulaca comprised of about 150 species, mostly distributed in arid tropical and subtropical regions, particularly Africa and South America, with a few species extending into temperate regions with some of them cultivated for medicinal or horticultural uses (Chung et al., 2008). It was also reported that the weed is found in all countries in Africa usually as a weed and it is rarely cultivated (Jansen, 2004). It is tolerant of a wide range of soils but prefers sand or sandy loam (PROTA, 2014). P. quadrifida is a significant weed in maize (Zea mays) and onions (Allium cepa) farm as reported by Kachare et al. (2005).

In Nigeria onion production is confirmed to be most concentrated in the Guinea and Savanna areas where cool conditions for bulb maturation, ripening and curing exists, but the bulk of production comes from Sokoto, Kano, Bauchi, Gombe, Kaduna, Plateau and Borno, Jigawa, Katsina and Kebbi States. (Norman, 1992; Anyanwu, 2003). Carlson and Kirby (2005), Qasem (2006) and Smith et al. (2011) confirmed that many authors have reported that onion plants are poor weed competitors and the poor competitive ability of the crop with weeds has been attributed to its initial slow growth and lack of adequate foliage to smother weeds.
The establishment of optimum population per unit area of the field is reported by (Singh and Singh, 2000) to be an essential factor that leads to maximum yield. With favourable conditions of sufficient soil moisture and nutrients, higher plant population is necessary to utilize all growth factors efficiently. Transplanting density, along with other factors has been investigated in several studies with onion (Boyhan et al., 2009). However, chemical weed control by pre-sowing, pre-emergence, early post-emergence and combinations of them are all effective for weed control (Shureskumar et al., 2016). The use of herbicides is one of the options left with the farmers to minimize crop weed competition at early growth stage of crop. Grema and Gashua (2014) reported that for effective weed management of the troublesome weed, the use of herbicides has been tried and observed to reduce labour requirement and its attendant’s costs, facilities, efficient weed control and also increase profitability in onion production.  

*P. quadrifida* has been a nuisance to onion grown in their farms with such characteristics of possessing the ability to survive desiccation and re-growth from small fragments of stem. The situation has been unbearable for the farmers due to difficulties in the control of the weeds. Hoe weeding has been the farmers practice in the affected area. Therefore, the objective of this study is to evaluate plant population and weed control methods on the performance of onion under chicken weed infestation field alongside other weed species.

**MATERIALS AND METHODS**

Field experiments were conducted at farmers’ field in 2017/2018 and 2018/2019 dry seasons at Birnin Kebbi, Kebbi State to assess the of effect of plant population and weed control methods on the management of Chicken weed alongside other weeds growing in onion field. The treatments consisted of factorial combination of three plant population (500,000, 333,333, 250,000 plants/ha) and twelve weed control methods (Pendimethalin at 1.0 kg a.i. ha⁻¹ + 1Hw; pendimethalin at 1.5 kg a.i. ha⁻¹ + fluazifop-p-butyl at 2.0 kg a.i. ha⁻¹; butachlor at 2.0 kg a.i. ha⁻¹ + 1Hw, butachlor at 2.8 kg a.i. ha⁻¹ + oxyfluorfen at 1.0 kg a.i. ha⁻¹; butachlor at 3.6 kg a.i. ha⁻¹; fluazifop-p-butyl at 2.0 kg a.i. ha⁻¹; oxyfluorfen at 1.0 kg a.i. ha⁻¹ + 1Hw; hoe weeding at 3 (WAT); hoe weeding at 3 and 6 WAT; weed free and weedy check) and arranged in a Randomized Complete Block Design replicated three times. The field was irrigated, manually tilled and plot sizes of 2m × 3m were constructed. To ascertain the nutrient composition of soil in the experimental field, composite soil samples were collected across the field and were analyzed for its physical and chemical properties. Poultry manure at the rate 4 t/ha was incorporated uniformly on each plot during construction, while NPK 15:15:15 at the rate of 120 Kg ha⁻¹ was applied at 3 and 6 WAT. Application of herbicides was done based on the treatments design. The plots were irrigated 4 days interval throughout the growing period. Data were collected on weed, growth and yield parameters. The data were subjected to analysis of variance (ANOVA) and treatment means separated by Duncan Multiple Range Test (DMRT) at p<0.05 using statistical analysis software (SAS, 2002).

**RESULTS**

**Physical and chemical properties of soil at the experimental site**

Physical and chemical analysis of soil from the experimental site at Birnin Kebbi in 2017/2018 and 2018/2019 dry season is presented Table 1. The result of the analysis revealed that the soil was sandy loam in both years. In 2017/2018, the soil pH (5.3%) was strongly acidic. Low Organic Carbon (0.04%), low Total Nitrogen (0.074%) and very low available phosphorus (0.63%). In 2018/2019, the pH (5.8%) was moderately acidic, low Organic Carbon (0.74), very low Total Nitrogen (0.042) and Available P. (0.71) were recorded. The Exchangeable cation (Ca, Mg, K, and Na) in both years were low. The Cation Exchange Capacity (CEC) was low (4.92) in 2017/2018 and higher (13.0) in 2018/2019.
### Table 1. Physical and chemical properties of soil at the experimental site in Birnin Kebbi

| Physical properties | 2017/2018 | 2018/2019 |
|---------------------|-----------|-----------|
| Sand %              | 69.6      | 71.7      |
| Clay %              | 9.4       | 5.5       |
| Silt %              | 21.0      | 22.5      |
| Textural class      | Sandy loam| Sandy loam|

### Chemical properties

|                  | 2017/2018 | 2018/2019 |
|------------------|-----------|-----------|
| pH in water      | 5.3       | 5.8       |
| Organic carbon (%)| 0.04      | 0.74      |
| Total nitrogen (%)| 0.074     | 0.042     |
| Available P (mg kg⁻¹) | 0.63      | 0.71      |

### Exchangeable bases

|          | 2017/2018 | 2018/2019 |
|----------|-----------|-----------|
| Ca (C mol kg⁻¹) | 0.65     | 0.65     |
| Mg (C mol kg⁻¹) | 0.30     | 0.90     |
| K (C mol kg⁻¹)  | 1.46     | 1.05     |
| Na (C mol kg⁻¹) | 0.83     | 0.52     |
| CEC (C mol kg⁻¹) | 4.92     | 13.0     |

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**Effect of plant population and weed control methods on weed cover score, weed control efficiency and crop injury score on onion at Birnin Kebbi**

Table 2 presents plant population and weed control methods on weed cover score, weed control efficiency and crop injury score. Results showed that plant population did not significantly (p<0.05) affect weed cover score, weed control efficiency and crop injury score in onion field.

Result on weed control methods showed that, in 2017/2018, application of pendimethalin at 1.0 and 1.5 kg a.i. ha⁻¹ followed by 1 Hw and fluazifop-p-butyl at 2.0 kg a.i. ha⁻¹ respectively, butachlor at 2.0 and 2.8 kg a.i. ha⁻¹ followed by 1 Hw and application of oxyfluorfen at 1.0 kg a.i. ha⁻¹ respectively significantly (p<0.05) recorded the lowest weed cover. Similar trend was noticed in plots with fluazifop-p-butyl at 2.0 kg a.i. ha⁻¹ at 6 WAT and weed free plots in 2017/2018. In 2018/2019, application of pendimethalin at 1.5 kg a. ha⁻¹ followed by fluazifop-p-butyl at 2.0 kg a.i. ha⁻¹ and the weed free plots recorded the lowest weed cover, though all the rates of pendimethalin and butachlor were at par including oxyfluorfen + 1 Hw. The highest weed cover was recorded in weedy check in both years. Highest weed control efficiency was recorded in weed free plots in both years which were comparable with plots that were sprayed with pendimethalin at 1.5 kg a.i. ha⁻¹ followed by fluazifop-p-butyl at 2.0 kg a.i. ha⁻¹ and pendimethalin at 2.0 kg a.i. ha⁻¹ in 2018/2019. The lowest weed control efficiency was observed in weedy check in both years.

Crop injury score was observed in both seasons. Crop planted in weedy check plots in 2017/2018 and those plots applied with fluazifop-p-butyl at 2.0 kg a.i. ha⁻¹ in 2018/2019 significantly recorded the highest crop injury. The plots with the slightest crop injury were noticed when butachlor at 2.0 kg a.i. ha⁻¹ followed by 1Hw at 6 WAT were used in both years.
Table 2: Effect of plant population and weed control methods on weed cover score, weed control efficiency and crop injury score on onion at Birnin Kebbi

| Treatments                          | Rate (kg a.i. ha$^{-1}$) | Weed cover score 2017 | Weed cover score 2018 | Weed cover score 2019 | Weed efficiency 2017 | Weed efficiency 2018 | Weed efficiency 2019 | Crop injury score 2017 | Crop injury score 2018 | Crop injury score 2019 |
|-------------------------------------|--------------------------|-----------------------|------------------------|------------------------|----------------------|-----------------------|------------------------|-----------------------|------------------------|------------------------|
| Plant population (plants/ha$^{-1}$) |                          |                       |                        |                        |                      |                       |                        |                      |                        |                        |
| 500,000                             |                          |                       |                        |                        |                      |                       |                        |                      |                        |                        |
| 23.61                               | 15.00d                   | 6.67cde               | 83.30ab                | 90.49ab                | 13.33de              | 10.56a-d              |                        |                      |                        |                        |
| 333,333                             |                          |                       |                        |                        |                      |                       |                        |                      |                        |                        |
| 24.72                               | 16.67d                   | 4.44e                 | 81.89ab                | 94.62a                 | 13.33de              | 10.00a-d              |                        |                      |                        |                        |
| 500,000                             |                          |                       |                        |                        |                      |                       |                        |                      |                        |                        |
| 23.75                               | 13.33d                   | 7.22cde               | 83.31ab                | 90.53ab                | 16.11bc              | 12.78ab               |                        |                      |                        |                        |
| 250,000                             |                          |                       |                        |                        |                      |                       |                        |                      |                        |                        |
| 2.8 fb 1.0                          | 18.89cd                  | 9.44cde               | 77.57abc               | 84.49abc               | 15.00bcd             | 11.67abc              |                        |                      |                        |                        |
| Butachlor                           |                          |                       |                        |                        |                      |                       |                        |                      |                        |                        |
| Butachlor fb                        | 3.6                      | 25.00bc               | 8.89cde                | 71.05cd                | 87.30ab              | 14.44cde              | 10.56a-d              |                        |                      |                        |
| Fluazifop-p-butyl                   | 2.0                      | 16.67d                | 13.33cde               | 81.33ab                | 80.32b               | 17.22ab               | 13.89a                |                        |                      |                        |
| Fluazifop-p-butyl                   | 1.0 fb 1HW               | 18.89cd               | 9.44cde                | 77.57abc               | 84.49abc             | 15.00bcd              | 11.67abc              |                        |                      |                        |
| Hoe weeding                         | 3 and 6 WAT              | 30.56b                | 19.44b                 | 65.48d                 | 73.52c               | 15.00bcd              | 10.00a-d              |                        |                      |                        |
| Hoe weeding                         | 3, 6 and 9 WAT           | 18.33cd               | 14.44bc                | 75.75bc                | 79.75bc              | 13.33de               | 8.33cd                |                        |                      |                        |
| Weed free                           |                          |                       |                        |                        |                      |                       |                        |                      |                        |                        |
| Weed free                           |                          |                       |                        |                        |                      |                       |                        |                      |                        |                        |
| Interactions                        |                          |                       |                        |                        |                      |                       |                        |                      |                        |                        |
| PP*WC                               | NS                       | NS                    | NS                     | NS                     | NS                   | NS                    | NS                     | NS                   | NS                     | NS                     |

Means with the same letter (s) in a treatment column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT). NS = not significant, *= significant at 5% level, fb = followed by, HW= hoe weeding, WAT= weeks after transplanting.

Effect of plant population and weed control methods on plant height, number of leaves and leaf area of onion at Birnin Kebbi

Growth parameters such as plant height, number of leaves and leaf area as affected by plant population and weed control methods are presented in Table 3. Result showed that growth parameters such as plant height, number of leaves and leaf area were not significantly affected by plant population at 9 WAT. All weed control methods significantly (p<0.05) affected the growth parameters of onion as shown in (Table 3). In 2017/2018, plant height increased with application of pendimethalin at 1.0 kg a.i. ha$^{-1}$ followed by one hoe weeding (1 Hw) at 6 WAT. Similar increase in plant height was observed in 2018/19 when pendimethalin at 1.5 kg a.i. ha$^{-1}$ followed by fluazifop-p-butyl at 2.0 kg a.i. ha$^{-1}$ and butachlor at 2.0 kg a.i. ha$^{-1}$ followed 1 Hw at 6 WAT were applied. Weedy check recorded the shortest plant in both years. Highest number of leaves and leaf area were observed with application of pendimethalin at 2.0 kg a.i. ha$^{-1}$ in 2017/2018 with butachlor at 2.0 kg a.i. ha$^{-1}$ followed by 1 HW at 6 WAT and pendimethalin at 1.5 kg a.i. ha$^{-1}$ supplemented by fluazifop-p-butyl at 2.0 kg a.i. ha$^{-1}$ in 2018/2019. Interaction of plant population and weed control treatment was observed in plant height at 9 WAT in 2018/2019. The result of the interaction as shown in Table 4 indicated that plant population of 250,000 plants/ha recorded the tallest plants in combination with application of pendimethalin at the rate of 2.0 kg a.i. ha$^{-1}$, while the shortest plants were recorded under plant population of 333,333 plants/ha with application of butachlor at 2.8 kg a.i. ha$^{-1}$ followed by oxyfluorfen at 1.0 kg a.i. ha$^{-1}$. 

Plant population and weed control treatment was observed in plant height at 9 WAT in 2018/2019. Interaction of plant population and weed control treatment was observed in plant height at 9 WAT in 2018/2019. The result of the interaction as shown in Table 4 indicated that plant population of 250,000 plants/ha recorded the tallest plants in combination with application of pendimethalin at the rate of 2.0 kg a.i. ha$^{-1}$, while the shortest plants were recorded under plant population of 333,333 plants/ha with application of butachlor at 2.8 kg a.i. ha$^{-1}$ followed by oxyfluorfen at 1.0 kg a.i. ha$^{-1}$. 

Means with the same letter (s) in a treatment column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT). NS = not significant, *= significant at 5% level, fb = followed by, HW= hoe weeding, WAT= weeks after transplanting.
### Table 3: Effect of Plant population and weed control methods on growth parameters of onion at 9 WAT at Birnin Kebbi

| Treatments | Rate (kg a.i. ha⁻¹) | 2017-2019 | 2018 | 2019 | 2017-2018 | 2018 | 2019 | 2017-2018 | 2018 | 2019 |
|------------|---------------------|-----------|------|------|-----------|------|------|-----------|------|------|
| Plant population (plants/ha⁻¹) | | | | | | | | | | |
| 500,000    | 36.83               | 40.57     | 5.61 | 7.05 | 3989.4    | 4436.2 | | | | |
| 333,333    | 36.87               | 41.39     | 5.58 | 7.13 | 4080.7    | 4555.5 | | | | |
| 250,000    | 37.16               | 39.30     | 5.56 | 7.00 | 4075.7    | 4332.9 | | | | |
| SE±        | 0.82                | 1.23      | 0.13 | 0.18 | 96.07     | 136.95 | | | | |
| Weed control methods | | | | | | | | | | |
| Pendimethalin | 1.0 fb 1HW          | 41.81a    | 44.27ab | 5.67a-d | 6.78bcd | 4109.1a-d | 4093.7cd | | | | |
| Pendimethalin fb | 1.5 fb 2.0          | 39.54ab   | 45.11a  | 5.78ab  | 7.56ab   | 4469.0ab  | 4955.6a  | | | | |
| Fluazifop-p-butyl | | | | | | | | | | |
| Pendimethalin | 2.0                 | 37.28abc  | 37.14cde | 6.11a  | 7.56ab  | 4608.7a  | 4879.4ab | | | | |
| Butachlor | 2.0 fb 1HW          | 38.74ab   | 47.20a  | 5.89abc | 7.89a    | 4244.5abc | 5202.2a  | | | | |
| Butachlor fb | 2.8 fb 1.0          | 36.49bc   | 35.35de | 5.33bcd | 6.44cd   | 3959.5bcd | 3896.0cd | | | | |
| Oxfluorfen | | | | | | | | | | |
| Butachlor | 3.6                 | 37.54abc  | 42.37abc | 6.00ab  | 6.56bcd  | 4137.3abc | 4477.7abc | | | | |
| Fluazifop-p-butyl | 2.0               | 33.34c    | 40.62a-d | 5.00d  | 6.00d    | 3679.2d   | 3442.5d  | | | | |
| Oxfluorfen | 1.0 fb 1HW          | 37.16abc  | 37.73cde | 5.44a-d | 6.89a-d  | 4120.4a-d | 4172.1bcd | | | | |
| Hoe weeding | 3 and 6 WAT         | 36.30bc   | 42.19a-d | 5.56a-d | 7.11abc  | 3994.2bcd | 4650.4abc | | | | |
| Hoe weeding 3, 6 and 9 WAT | | | | | | | | | | |
| Weed free | 36.04bc              | 41.09a-d  | 5.56a-d | 7.33abc | 3646.7d  | 4528.9abc | | | | |
| Weedy check | 33.82c              | 31.26e    | 5.22cd | 7.44abc | 3714.3cd | 4514.1abc | | | | |
| SE±        | 1.65                | 2.46      | 0.26  | 0.36  | 192.15   | 273.90   | | | | |

Means with the same letter (s) in a treatment column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT). NS = not significant, *= significant at 5% level, fb = followed by, HW = hoe weeding, WAT = weeks after transplanting.

### Table 4: Interaction of plant population and weed control methods on plant height of onion at 9 WAT during 2018/2019 dry season at Birnin Kebbi

| Weed control methods | Rate (kg a.i. ha⁻¹) | 500,000 | 333,333 | 250,000 |
|----------------------|---------------------|---------|---------|---------|
| Pendimethalin        | 1.0 fb 1HW          | 38.37i-m| 29.05o  | 44.03d-g |
| Pendimethalin fb     | 1.5 fb 2.0          | 48.80abc| 49.17ab | 37.36k-n |
| Fluazifop-p-butyl    | 2.0                 | 34.27mn | 47.93a-d| 50.62a  |
| Butachlor            | 2.0 fb 1HW          | 49.98ab | 46.80a-e| 44.84c-f|
| Butachlor fb         | 2.8 fb 1.0          | 40.76g-k| 26.39p  | 38.90i-l|
| Oxfluorfen           | 3.6                 | 38.01j-m| 46.55a-e| 37.33k-n|
| Fluazifop-p-butyl    | 2.0                 | 28.16o  | 35.68imn| 29.95op |
| Oxfluorfen           | 1.0 fb 1HW          | 36.25imn| 41.67j-f| 35.28mn |
| Hoe weeding 3 and 6 WAT | 39.67h-l         | 43.94d-g| 42.98i-e|
| Hoe weeding 3, 6 and 9 WAT | 42.67ghf     | 41.76j-f| 37.69-j-n|
| Weed free            | 43.45d-g           | 44.53def| 35.31lmm|
| Weedy check          | 46.58a-e           | 43.22d-h| 37.33j-n|
| SE±                  | 4.26               |         |         |         |
Means with the same letter (s) in a treatment column or rows are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT). fb = followed by, HW= hoe weeding, WAT= weeks after transplanting

**Effect of plant population and weed control methods on yield parameters of onion and pooled data at Birnin Kebbi**

Yield parameters such as cured bulb and marketable bulb yield as affected by plant population and weed control methods is presented in Table 5. Result showed that cured bulb and marketable bulb yields were significantly (p<0.05) affected by plant population in both seasons and at pooled. Plant population of 500,000/plant performed better and therefore recorded the highest cured bulb yield in both years and at pooled data. Similar trends was followed in terms of marketable bulb yield, while the lowest cured bulb and marketable bulb yield were observed in the weedy check plots. Weed control methods significantly (p<0.05) affected cured bulb and marketable bulb yield in both years and at pooled. Pre-emergence application of butachlor at the rate of 2.0 kg a.i. ha⁻¹ supplemented by one hoe weeding in both seasons and at pooled and application of pendimethalin at the rate of 1.0 kg a.i. ha⁻¹ supplemented with one hoe weeding and at pooled in 2017/2018 significantly (p<0.05) produced the highest cured bulb yield, though the result was at par with the result obtained in plots with weeding at 3, 6 and 9 WAT. Pendimethalin at the rate of 1.0 kg a.i. ha⁻¹ supplemented with one hoe weeding in 2017/2018 and at pooled data recorded the highest marketable bulb yield. The lowest cured bulb and marketable bulb yields were recorded in weedy check. Interaction of factors on cured bulb and marketable bulb yield in the pooled data was observed (Table 5). The result of the interaction on cured bulb yield as presented in Table 6 showed that the highest cured bulb yield was achieved with plant population of 500,000 plants/ha with the use of butachlor at 2.0 kg a.i. ha⁻¹ followed by one hoe weeding, while the lowest cured bulb was recorded under weedy check with plant population of 250,000 plants/ha. The highest marketable bulb yield was achieved with plant population of 333,333 plants/ha with pendimethalin at 1.0 kg a.i. ha⁻¹ followed by one hoe weeding, while the lowest marketable bulb yield was recorded under weedy check (Table 7).

**Table 5: Effect of plant population and weed control methods on cured and marketable bulb yield of onion during the 2017/2018 and 2018/2019 dry seasons at Birnin Kebbi**

| Treatment                  | Cured bulb yield | Marketable bulb yield |
|----------------------------|------------------|-----------------------|
|                            | Rate             | 2017-2018 2018-2019 Pooled 2018-2019 2017-2018 Pooled |
| **Plant population (plants/ha⁻¹)** |                  |                       |
| 500,000                    | 3809.2a 3809.2b | 5759.7a 5759.7b | 4784.4a 4784.4b | 470.3a 470.3b | 801.7a 801.7b | 636.0a 636.0b |
| 333,333                    | 2633.2b 2633.2b | 4275.9b 4275.9b | 3454.6b 3454.6b | 385.2b 385.2b | 569.0b 569.0b | 476.1b 476.1b |
| 250,000                    | 1979.6c 1979.6c | 3063.2c 3063.2c | 2512.4c 2512.4c | 274.6c 274.6c | 382.7c 382.7c | 328.7c 328.7c |
| SE±                        | 218.53 218.53   | 405.22 405.22    | 186.41 186.41   | 19.1 19.1    | 44.8 44.8    | 28.9 28.9    |
| **Weed Control methods**   |                  |                       |
| Pendimethalin 1.0 fb 1HW   | 3688.3ab 3688.3ab| 6209.0a 6209.0a  | 4946.3a 4946.3a  | 493.6a 493.6b  | 452.8 452.8 | 473.2ab 473.2ab |
| Pendimethalin fb 1.5 2.0   | 3645.1abc 3645.1abc| 5606.0ab 5606.0ab| 4575.3ab 4575.3ab| 439.8ab 439.8ab| 709.0 709.0 | 570.3ab 570.3ab |
| Fluazifop-p-butyl         | 2.0 2.0 fb 1.0  | 2874.1bcd 2874.1bcd | 3826.a-d 3826.a-d| 3350.0bc 3350.0bc | 380.8-a 380.8-a | 508.4 508.4 | 444.6ab 444.6ab |
| Butachlor 2.0 fb 1HW      | 4403.7a 4403.7a | 6222.0a 6222.0a | 5313.0a 5313.0a | 462.1ab 462.1ab | 776.7 776.7 | 619.4a 619.4a |
| Butachlor fb 2.8 1.0      | 2198.1cde 2198.1cde | 4196.0a-d 4196.0a-d| 3197.0bc 3197.0bc | 328.7cd 328.7cd | 539.4 539.4 | 434.0ab 434.0ab |
| Oxyluorufen               |                  |                       |
| Butachlor 3.6             | 2487.4b 2487.4b-e| 3467.0bcd 3467.0bcd | 2977.0bc 2977.0bc | 325.4cd 325.4cd | 467.2 467.2 | 396.3b 396.3b |
| Fluazifop-p-butyl 2.0      | 3000.0bcd 3000.0bcd | 3087.0bcd 3087.0bcd| 3043.0bc 3043.0bc | 393.7abc 393.7abc | 418.7 418.7 | 406.2b 406.2b |
| Oxyluorufen 1.0 fb 1HW     | 2052.2de 2052.2de | 2804.0cd 2804.0cd | 2427.0cd 2427.0cd | 370.5bcd 370.5bcd | 528.4 528.4 | 449.5ab 449.5ab |
| Hoe weeding 3 and 6 WAT    | 1948.1de 1948.1de | 4550.0abc 4550.0abc | 3248.0bc 3248.0bc | 347.2cd 347.2cd | 578.2 578.2 | 462.7ab 462.7ab |
| Hoe weeding 3, 6 and 9 WAT | 3179.6a 3179.6a | 5263.0abc 5263.0abc | 4221.3ab 4221.3ab | 348.8bcd 348.8bcd | 688.5 688.5 | 518.6ab 518.6ab |
| Weed free                 | 3000.0bcd 3000.0bcd | 5511.0ab 5511.0ab | 4255.7ab 4255.7ab | 360.7bcd 360.7bcd | 686.9 686.9 | 523.8ab 523.8ab |
| Weedy check               | 1316.3e 1316.3e | 1655.0d 1655.0d | 1485.7d 1485.7d | 261.7d 261.7d | 667.8 667.8 | 464.8ab 464.8ab |
| SE±                       | 437.0 437.0    | 810.44 810.44     | 372.82 372.82   | 38.1 38.1    | 89.5 89.5    | 57.8 57.8    |

Means with the same letter (s) in a treatment column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT). NS= not significant, *= significant at 5% level, fb = followed by, HW= hoe weeding, WAT= weeks after transplanting.
RESPONSE OF ONION (*Allium cepa* L.) TO PLANT POPULATION AND WEED CONTROL METHODS IN A CHICKEN WEED

| Weed methods | control | Rate (kg a.i. ha⁻¹) | 500,000 | 333,333 | 250,000 |
|--------------|---------|---------------------|---------|---------|---------|
| Pendimethalin | 1.0 fb 1HW | 3733.0b-e | 4267.0a-d | 3050.0b-f |
| Pendimethalin fb | 1.5 fb 2.0 | 5267.0ab | 3141.0b-f | 2228.0c-f |
| Fluazifop-p-butil | 2.0 | 3067.0b-f | 2778.0b-f | 2778.0b-f |
| Pendimethalin fb | 2.0 fb 1HW | 6400.0a | 4444.0abc | 2367.0c-f |
| Butachlor fb | 2.8 fb 1.0 | 3300.0b-f | 2044.0c-f | 1250.0ef |
| Oxyfluorfen | 3.6 | 3333.0b-f | 2029.0c-f | 2100.0c-f |
| Fluazifop-p-butil | 2.0 | 3900.0b-f | 2600.0c-f | 2500.0c-f |
| Oxyfluorfen | 1.0 fb 1HW | 3811.0b-f | 1029.0f | 1517.0ef |
| Hoe weeding | 3 and 6 WAT | 2511.0c-f | 1667.0def | 1667.0def |
| Hoe weeding | 3, 6 and 9 WAT | 4467.0abc | 3689.0b-e | 1383.0ef |
| Weed free | 4467.0abc | 2600.0c-f | 1933.0c-f |
| Weedy check | 1654.0def | 1311.0ef | 983.0f |
| SE± | | | | 757.0 |

Means with the same letter(s) in a treatment column or rows are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT). fb = followed by, HW= hoe weeding, WAT= weeks after transplanting.

**DISCUSSION**

The soil at the experimental field was sandy loam with low nutrient contents and cation exchange capacity. The low nutrient status may be as a result of intensive and regular use of the land for agricultural activities. This is in line with the report of Tully *et al.* (2015) who reported that expansion and intensification of agriculture in an effort to feed the growing population is a primary source of soil degradation. There was no significant (p<0.05) effect of plant population on onion in terms of growth and weed parameters, but significant difference (p<0.01) was observed with yield parameters. Siliquini *et al.* (2015) also reported that even with differences in leaf area absolute value, the effect of plants growing at different densities were similar.

Statistical analysis has revealed in this study that weed control methods played a greater role in weed reduction. Effective reduction in weed cover was consistent with the pre-emergence applications of pendimethalin and butachlor at all the rates evaluated including weed free during the first year, though pendimethalin at 2.0 kg a.i. ha⁻¹ supplemented with fluazifop-p-butil at 2.0 kg a.i. ha⁻¹ and weed free were superior over other methods during the second year. This result revealed that pre-emergence herbicides treatments used in this study have shown sufficient reduction of weeds compared to other treatments. Omosore *et al.* (2016) reported that significantly least weed cover score was produced with pre-emergence application of herbicide when supplemented with one hoe weeding, while the highest

| Weed methods | control | Rate (kg a.i. ha⁻¹) | 500,000 | 333,333 | 250,000 |
|--------------|---------|---------------------|---------|---------|---------|
| Pendimethalin | 1.0 fb 1HW | 325.1d-h | 763.0a | 392.6c-h |
| Pendimethalin fb | 1.5 fb 2.0 | 568.1abc | 484.2c-f | 266.9c-h |
| Fluazifop-p-butil | 2.0 | 472.9c-g | 391.6c-h | 277.8c-h |
| Pendimethalin fb | 2.0 fb 1HW | 694.2ab | 394.3c-h | 297.8e-h |
| Butachlor fb | 2.8 fb 1.0 | 482.7c-f | 254.4gh | 248.9gh |
| Oxyfluorfen | 3.6 | 442.1c-g | 274.7e-h | 259.4gh |
| Fluazifop-p-butil | 2.0 | 536.6bcd | 373.3c-h | 271.3e-h |
| Oxyfluorfen | 1.0 fb 1W | 491.1cde | 346.7c-h | 275.9e-h |
| Hoe weeding | 3 and 6 WAT | 425.3c-g | 319.2d-h | 297.2e-h |
| Hoe weeding | 3, 6 and 9 WAT | 410.5c-g | 386.5c-h | 249.4gh |
| Weed free | 436.2c-g | 360.5c-h | 285.4e-h |
| Weedy check | 359.3c-h | 249.8gh | 176.4h |
| SE± | | | | 186.2 |

Means with the same letter(s) in a treatment column or rows are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT). fb = followed by, HW= hoe weeding, WAT= weeks after transplanting.
weed cover was noticed in the control plots. The highest weed cover was found in the weedy check which was predominantly Chicken weed. Highest percentage reduction in weed population with highest weed control efficiency was revealed under weed free plots, though at par with pre-emergence application of pendimethalin. This result corroborate the work of Kashid (2019) who reported that significant weed reduction and weed index with highest weed control efficiency was revealed in weed free plots. Severe crop injury score was noticed in weedy check plots which were comparable with post-emergence application of fluazifop-p-butyl at 2.0 kg a.i. ha\(^{-1}\). This might be attributed to the phytotoxic effect of fluazifop-p-butyl due to its post emergence application on the crop. Severity symptoms of crop injury according to Sathya et al. (2013) were observed with increase rate of herbicide application. The lowest crop injury score was recorded with pre-emergence application of butachlor at 2.0 kg a.i. ha\(^{-1}\) followed by one hoe weeding.

In the consideration of weed control methods on growth parameters, plots applied with pre emergence application of pendimethalin at 1.0 and 1.5 kg a.i. ha\(^{-1}\) supplemented with one hoe weeding and fluazifop-p-butyl respectively produced taller plants and leaf area. Likewise, pendimethalin at 2.0 kg a.i. ha\(^{-1}\) also recorded the highest number of leaves and leaf area followed by butachlor at 2.0 kg a.i. ha\(^{-1}\) supplemented by one hoe weeding in terms of plant height, number of leaves and leaf area. This result implies that integration of herbicides rate with conventional method will go a long way in reducing the menace of weed for better growth of onion. To obtain decrease in weed and increase in growth of crops, Yadav et al. (2017) reported that integration of pre-emergence application of pendimethalin at 2.0 kg a.i. ha\(^{-1}\) along with one hand weeding resulted in lower weed population. Cured bulb and marketable bulb yield were increases with pre-emergence application of pendimethalin and butachlor at 1.0 and 2.0 kg a.i. ha\(^{-1}\) followed by one hoe weeding respectively. These observations are in accordance with Kalhapure and Shete (2012) who reported that higher yield attributes of onion was as a result of pre emergence application of pendimethalin at 1.0 kg a.i. ha\(^{-1}\) followed by one hoe weeding. Imoloame (2017) also stressed the need for integration of herbicides followed by one hoe weeding to be more effective in weed control and promotion of higher yield in many crops. Interaction of factors have shown that taller plants were influenced by the application of pendimethalin at 2.0 kg a.i. ha\(^{-1}\) and 1.5 kg a.i. ha\(^{-1}\) in plots with 250,000 plants/ha. However, cured and marketable bulb yields were generally favoured when butachlor at 2.0 kg a.i. ha\(^{-1}\) and pendimethalin at 1.0 kg a.i. ha\(^{-1}\) followed by one hoe weeding was applied in plots with plant population of 500,000 and 333,333 plants per hectare respectively. This result is in line with the report of Zubair et al. (2010) who stated that pre-emergence application of pendimethalin on weed control methods was recommended for better growth of onion.

**CONCLUSION**

Findings of this research confirmed that all weed control treatments made reasonable contributions to the control of chicken weed alongside other weed species in the study area. For better control of chicken weeds and other weed species, the use of plant population of 500,000 plants/ha supported with pre-emergence application of pendimethalin at 1.0 kg a.i. ha\(^{-1}\) two days after transplanting followed by one hoe weeding at six weeks after transplanting or the use of butachlor at 2.0 kg a.i. ha\(^{-1}\) at two days after transplanting followed by one hoe weeding at 6 weeks after transplanting performed better than the other methods. For effective control of chicken weed alongside other weed species in onion field, pendimethalin at the rate of 1.0 or butachlor at the rate of 2.0 kg a.i. ha\(^{-1}\) followed by one hoe weeding respectively can be recommended.

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**REFERENCE**

Anyawu, B. O., 2003. Agricultural Science for Schools and Colleges. Africa First Publishers, Onisha, Nigeria. in: Ojo, M. A, Mohammed, U. S, Adeniji, B and Ojo, A. O. Profitability and Technical Efficiency in Irrigated Onion Production Under Middle Rima Valley Irrigation Project In Goronyo, Sokoto State Nigeria. Continental Journal of Agricultural Science 3:7-14, 2009.

Boyhan, G. E., Torrance, R. L., Cook, J., Riner, C. and Hill, C. R., 2009. Plant population, transplant size, and variety effect on transplanted Short-day onion production. Hort Technology, vol. 19 (1): PP. 145-151

Carlson, L. and Kirby, D., 2005. Effect of herbicide rate and application timing on weed control in dehydrator onion. Res. Prog. Rpt. No. 115. University of California Intermountain Research and Extension Center, Tulelake, CA.

Chung, S-W, Domingo A. Madulid and Hsu, T. H., 2008. Portulaca psammotropha Hance (Portulacaceae), a Neglected Species in the Flora of Taiwan and the Philippines. Taiwania, 53 (1): 90 - 95

Gilbert, M. G. and Phillips, S. M., 2000. A review of the opposite-leaved species of Portulaca in Africa and Arabia. Kew Bulletin, 55(4):769-802

Grema, I. J. and Gashua, A. G., 2014. Economic analysis of onion production along River Komadugu area of Yobe State, Nigeria. Journal of Agriculture and Veterinary Science. 7 (1): 5 – 11
Grubben, J. H. and Denton, D. A., 2004. Plant resources of tropical Africa. PROTA Foundation, Wageningen; Back huys, Leiden; CTA, Wageningen.

Imoloame, E. O., 2017. Eulaion of hecide mixtures and weed control method in maize (Zea mays) production in the Southern Guinea Agro-Ecology of Nigeria. Nigeria journal of Weed Science, vol. 30: Pp 25 – 39

Jansen, P. C. M., 2004. Portulaca quadrifida. In: PROTA. Grubben, G. J. H. and Denton, O. A. Editors. PROTA (Plant resources of Tropical Resource Vegetables de l' Afrique tropicale, Wageningen, Netherlands. http://www.prota4u.org/search.asp Access 17/05/2017.

Kachare, M., Pandey, S. and Kumar, S., 2005. Integrated weed management in Kharif onion (Allium cepa L.). Farm Science Journal, 14(2):89 – 90

Kalhapure, A. H. and Shete, B. T., 2012. Integrated weed management in onion. Indian Journal of Weed Science, vol. 44 (2): 88–91

Kashid, N. V., 2019. Integration of post-emergence herbicide application with hand weeding for managing weeds in transplanted rice. Indian Journal of Weed Science, 51 (2) 206-208.

Lei, X., Li, J., Liu, B., Zhang, N. and Liu, H. (2015). Separation and Identification of four new compounds with antibacterial activity from Portulaca oleracea L. Molecules, 20:16375-16387.

Norman, J. C., 1992. Tropical vegetable crops. Stockwell Ltd, Great Britain, 252pp.

Nyffeler, R. and Eggli, U., 2010. Disintegrating Portulaceae: A new familial classification of the suborder Portulacineae (Caryophyllales) based on molecular and morphological data. Taxon 59: 227–240.

Omisore, J. K., Aboyei, C. M. and Daramola, O. F., 2016. Comparative evaluation of weed control methods on cowpea (Vigna unguiculata (L.) Walp) production in the Savanna Agro-ecological zone of Nigeria, Scientia Agriculturae, vol. 14 (3): Pp. 279 - 283

PROTA, 2014. PROTA4U web database. Grubben, G. J. H and Denton, O. A., eds. Wageningen, Netherlands: Plant Resources of Tropical Africa. http://www.prota4u.org/search.asp

Qasem, J. R., 2006a. Chemical weed control in seedbed sown onion (Allium cepa L.). Journal of Crop Protection. 25: pp. 618–622.

SAS. 2002. Statistical Analysis System. SAS Institute Inc. Cary, NC., USA (version 9.0) Sathya, P. R., Chinnusamy, C., Manickasundaram, P. and Murali, A., 2013. Evaluation of new formulation of oxyfluorfen (23.5% EC) for weed control efficacy and bulb yield in onion. American Journal of Plant Science, vol. 4: Pp. 890-895.

Sureshkumar, R., Ashoka, R. R. and Ravichandran, S., 2016. Effect of weed and their management in transplanted Rice – A Review. International Journal of Research in applied, Natural and Social Sciences, vol. 4 (11). 165

Singh, S. and Singh, J., 2000. National symposium on onion and garlic, production and postharvest management challenges and strategies, Abstract. Pp. 226.

Siliquini, O. A., Orioli, G. A. and Lobartini, J. C., 2015. Onion yield as affected by plant density, nitrogen level and loss of leaf area. International Journal of Experimental Botany, vol.84: Pp. 338 - 344

Smith, R., Cahn, M., Cantwell, M., Koine, S., Natwick, E. and Takele, E., 2011. Green onion production in California. Vegetable Production Service. University of California, Agriculture and Natural Resources.

Tully, K., Sullivan, C., Weil, R. and Sanchez, P., 2015. The State of soil degradation in Sub-Saharan Africa: Baselines, Trajectories, and Solutions. Sustainability, vol. 7 (6) pp. 6523-6552

Yadav, T., Nisha, K. C., Chopra, N. K., Yadav, M. R., Kumar, R., Rathore, D. K., Soni, P. G., Makarana, G., Tamta, A., Kushwah, M., Ram, H., Meena, R. K. and Singh, M., 2017. Weed management in cowpea - A Review. International Journal of Current Microbiology and Applied Sciences, 6 (2): 1373-1385

Yakubu, A. I., 2000. Mulching for weed control in onion production in the Sokoto Rima valley. Proceedings of the 18th HORTSON Conference, IAR, ABU, Zaria, May 28-June 1, 2000. Pp. 80-84.

Zhou, Y. X., Xin, H. L., Rahman, K., Wang, S. J., Peng, C. and Zhang, H., 2015. Portulaca oleracea L. A review of phytochemistry and pharmacological effects. Biomedical Research Institute, 925631.

Zubair, M., Rahman, H., Jillani, M. S., Kiran, M., Waseem, M. K., Khattak, A.M., Rahim, A., Khan, A. A., Quayyum, A. and Wahab, A., 2009. Comparison of Different Weed Management Practices in Onion (Allium cepa L. Under Agroclimatic Conditions of Dera Ismail Khan, Pakistan. Pakistan Journal of Weed Sci. Res. 15 (1): 45-51.