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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} + fluazifop-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}; 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). 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} + fluazifop-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 fluazifop-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 Eggli, 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.

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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 farmer's 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^{-1}) 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.

Table1. Physical and chemical properties of soil at the experimental site in Birnin Kebbi

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

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 2018/19 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

		Weed cover score		Weed control efficiency		Crop injury score	
Treatments	Rate (kg a.i. ha^{-1})	2017-2018	2018-2019	2017-2018	2018-2019	2017-2018	2018-2019
Plant population (plants/ha^{-1})							
500,000		23.61	13.89	73.14	79.39	15.27	9.86
333,333		24.72	15.41	71.39	81.03	14.30	10.41
250,000		23.75	15.56	70.99	77.59	15.13	11.11
SE±		1.43	1.43	1.52	2.02	0.49	0.68
Weed control methods							
Pendimethalin	1.0 fb 1HW	15.00d	6.67cde	83.30ab	90.49ab	13.33de	10.56a-d
Pendimethalin fb Fluazifop-p-butyl	1.5 fb 2.0	16.67d	4.44e	81.89ab	94.62a	13.33de	10.00a-d
Pendimethalin	2.0	19.44cd	5.56de	76.97abc	92.19a	16.11bc	8.89bcd
Butachlor	2.0 fb 1HW	16.67d	10.00cde	79.97ab	84.24abc	12.22e	7.22d
Butachlor fb Oxyfluorfen	2.8 fb 1.0	13.33d	7,22cde	83.31ab	90.53ab	16.11bc	12.78ab
Butachlor	3.6	25.00bc	8.89cde	71.05cd	87.30ab	14.44cde	10.56a-d
Fluazifop-p-butyl	2.0	16.67d	13.33bcd	81.33ab	80.32bc	17.22ab	13.89a
Oxyfluorfen	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		13.33d	5.00e	85.48a	94.61a	13.33de	9.44bcd
Weedy check		84.44a	75.00a	0.00e	0.00e	19.44a	12.22abc
SE±		2.86	2.87	3.04	4.04	0.98	1.37
Interaction							
PP*WC		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}.

Table 3: Effect of Plant population and weed control methods on growth parameters of onion at 9 WAT at Birnin Kebbi

		Plant height (cm)		Number of leaves/plant		Leaf area (cm)	
Treatments	Rate (kg a.i. ha^{-1})	2017-2018	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 Fluazifop-p-butyl	1.5 fb 2.0	39.54ab	45.11a	5.78abc	7.56ab	4469.0ab	4955.6a
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 Oxyfluorfen	2.8 fb 1.0	36.49bc	35.35de	5.33bcd	6.44cd	3959.5bcd	3896.0cd
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
Oxyfluorfen	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	35.31bc	40.70a-d	5.44a-d	7.22abc	3900.6cd	4485.8abc
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
Interaction							
PP*WC		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

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

		Plant population (plants/ha)		
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 Fluazifop-p-butyl	1.5 fb 2.0	48.80abc	49.17ab	37.36k-n
Pendimethalin	2.0	34.27mn	47.93a-d	50.62a
Butachlor	2.0 fb 1HW	49.98ab	46.80a-e	44.84c-f
Butachlor fb Oxyfluorfen	2.8 fb 1.0	40.76g-k	26.39p	38.90i-l
Butachlor	3.6	38.01j-m	46.55a-e	37.33k-n
Fluazifop-p-butyl	2.0	28.16o	35.68lmn	29.95op
Oxyfluorfen	1.0 fb 1HW	36.25lmn	41.67f-j	35.28mn
Hoe weeding	3 and 6 WAT	39.67h-l	43.94d-g	42.98e-i
Hoe weeding	3, 6 and 9 WAT	42.67fgh	41.76f-j	37.69j-n
Weed free		43.45d-g	44.53def	35.31lmn
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 500,000p/ha 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 recorde 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

		Cured bulb yield			Marketable bulb yield		
Treatment	Rate (kg a.i. ha^{-1})	2017-2018	2018-2019	Pooled	2018-2019	2017-2018	Pooled
Plant population (plants/ha^{-1})							
500,000		3809.2a	5759.7a	4784.4a	470.3a	801.7a	636.0a
333,333		2633.2b	4275.9b	3454.6b	385.26b	569.0b	476.1b
250,000		1979.6c	3063.2c	2512.4c	274.6c	382.7c	328.7c
SE±		218.53	405.22	186.41	19.1	44.8	28.9
Weed Control methods							
Pendimethalin	1.0 fb 1HW	3688.3ab	6209.0a	4946.3a	493.6a	452.8	473.2ab
Pendimethalin fb Fluazifop-p-butyl	1.5 fb 2.0	3645.1abc	5606.0ab	4575.3ab	439.8ab	700.9	570.3ab
Pendimethalin	2.0	2874.1bcd	3826a-d	3350.0bc	380.8a-d	508.4	444.6ab
Butachlor	2.0 fb 1HW	4403.7a	6222.0a	5313.0a	462.1ab	776.7	619.4a
Butachlor fb Oxyfluorfen	2.8 fb 1.0	2198.1cde	4196.0a-d	3197.0bc	328.7cd	539.4	434.0ab
Butachlor	3.6	2487.4b-e	3467.0bcd	2977.0bc	325.4cd	467.2	396.3b
Fluazifop-p-butyl	2.0	3000.0bcd	3087.0bcd	3043.0bc	393.7abc	418.7	406.2b
Oxyfluorfen	1.0 fb 1HW	2052.2de	2804.0cd	2427.0cd	370.5bcd	528.4	449.5ab
Hoe weeding	3 and 6 WAT	1948.1de	4550.0abc	3248.0bc	347.2cd	578.2	462.7ab
Hoe weeding	3, 6 and 9 WAT	3179.6a	5263.0abc	4221.3ab	348.8bcd	688.5	518.6ab
Weed free		3000.0bcd	5511.0ab	4255.7ab	360.7bcd	686.9	523.8ab
Weedy check		1316.3e	1655.0d	1485.7d	261.7d	667.8	464.8ab
SE±		437.06	810.44	372.82	38.1	89.5	57.8
Interaction							
PP*WC		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

Table 6. Interaction of plant population and weed control methods on cured bulb yield at pooled data in Birnin Kebbi.

		Plant population (plants/ha^{-1})		
Weed control methods	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 Fluazifop-p-butyl	1.5 fb 2.0	5267.0ab	3141.0b-f	2228.0c-f
Pendimethalin	2.0	3067.0b-f	2778.0b-f	2778.0b-f
Butachlor	2.0 fb 1HW	6400.0a	4444.0abc	2367.0c-f
Butachlor fb Oxyfluorfen	2.8 fb 1.0	3300.0b-f	2044.0c-f	1250.0ef
Butachlor	3.6	3333.0b-f	2029.0c-f	2100.0c-f
Fluazifop-p-butyl	2.0	3900.0b-f	2600.0c-f	2500.0c-f
Oxyfluorfen	1.0 fb 1HW	3611.0b-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

Table 7. Interaction of plant population and weed control treatments on marketable bulb yield at pooled data in Birnin Kebbi.

		Plant population (plants/ha)		
Weed control methods	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 Fluazifop-p-butyl	1.5 fb 2.0	568.1abc	484.2c-f	266.9c-h
Pendimethalin	2.0	472.9c-g	391.6c-h	277.8c-h
Butachlor	2.0 fb 1HW	694.2ab	394.3c-h	297.8e-h
Butachlor fb Oxyfluorfen	2.8 fb 1.0	482.7c-f	254.4fgh	248.9gh
Butachlor	3.6	442.1c-g	274.7e-h	259.4fgh
Fluazifop-p-butyl	2.0	536.6bcd	373.3c-h	271.3e-h
Oxyfluorfen	1.0 fb 1W	491.1cde	346.7c-h	273.9e-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.c-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

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 ($p<0.0$) 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-butyl 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. Omisore *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 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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