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PLANT POPULATION AND WEED CONTROL EFFECTS ON BULB SIZE DISTRIBUTION OF ONION (*Allium cepa* L.) UNDER CHICKEN WEED (*Portulaca quadrifida* L.) INFESTED FIELD

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ABSTRACT
Plant population and weed management are among major factors constraining onion production. Therefore, field trial was conducted in Birnin Kebbi, Nigeria during the 2017/2018 and 2018/2019 dry seasons to assess the bulb size distribution of onion under the influence of plant population and weed control practice. The treatments was made of three plant population (500,000, 333,333 and 250,000 plants/ha) and weed control methods (pendimethalin @ 1.0 kg a.i. ha^{-1} + 1 Hw: pendimethalin @ 1.5 kg a.i. ha^{-1}: pendimethalin @ 2.0 kg a.i. ha^{-1}: butachlor @ 2.0 kg a.i. ha^{-1} + 1 Hw: butachlor @ 2.8 kg a.i. ha^{-1}: butachlor @ 3.6 kg a.i. ha^{-1}: fluaxifop-P-butyl @ 2.0 kg a.i. ha^{-1}: oxyfluorfen @ 1.0 kg a.i. ha^{-1} + 1 Hw: two weeding at 3 and 6 weeks after transplanting (WAT): three weeding at 3, 6 and 9 WAT: weed free and weedy check). The experiment was laid out in Randomized Complete Block Design and replicated three times. Results showed that onion bulb size distribution was not significantly affected with plant population treatments. The use of pendimethalin and butachlor at 1.0 and 2.0 kg a.i. ha^{-1} two days after transplanting followed by one hoe weeding respectively at 6 WAT recorded the highest bulb size distribution of onion. Weeding 3 times was second best and it can serve as an alternative to the aforementioned practice. It can be concluded that the integration of two methods such as pendimethalin at 1.0 kg a.i ha^{-1} or butachlor at 2.0 kg a.i ha^{-1} followed by one hoe weeding at 6 WAT was significantly superior to other methods and therefore, recommended for onion farmers in the study area as best practice for weed control.

Key words: *Onion, bulb size, plant population, herbicide, distribution*

INRODUCTION

Onion (*Allium cepa* L.) is a herbaceous biennial bulbous monocot that grows up to 90 cm tall and it is an annual crop for bulb production (Akobundu *et al.*, 2016). It is extremely a very important vegetable crop that is not grown for local consumption alone, but also as highest foreign exchange earner among the fruits and vegetables. Onion is an indispensable item in every kitchen as condiment and vegetable and one of the richest sources of flavonoid in the human diet. Gambo *et al.* (2008) reported that onion is consumed in different ways by different people and forms an essential part of the traditional daily diet, while Aliyu *et al.* (2016) confirmed that onion is grown primarily for its bulb often used for flavouring the local stew, other parts of onion that are considerably important include the fresh bulb and leaves which are mostly used as seasonings or as vegetables in stews. Onion is grown in a wide range of environmental condition, but it thrives best at mild climate without excessive rainfall or extremes of heat and cold (Jilani *et al.* 2010) and it is widely grown throughout the world (Pradeepkumar *et al.*, 2008). The leading African countries in onion production include Egypt, Algeria, Morocco, Nigeria, South Africa and Niger. The greater part of onion production in Nigeria is undertaken in the northern part of the country specifically states of Kebbi, Kano, Sokoto, Borno, Bauchi, Jigawa, Katsina and Zamfara (Dauda *et al.*, 2016).

Plant population is a critical factor in onion production. The establishment of optimum population per unit area of the field is reported by Singh and Singh (2000) to be an essential factor that led to maximum yield. Plant population has the influence on growth, yield and quality of onion bulbs (Brewster, 1994). Brewster, (1994) further stated that one of the critical production decisions that onion growers must address before planting is the selection of an optimum plant population.

Weeds are one of the major plant protection problems in onion fields. They compete with onions for light, nutrients, water and space while harboring several harmful insects and pathogens (Uygur *et al*., 2010). Controlling weed development during the onion crop cycle is essential to obtain high yields and marketable products. Onions do not compete well with weeds because they are slow growing and can suffer from successive flushes of weeds.

Chicken weed (*Portulaca quadrifida* L.) belongs to the family Portulacaceae (Das and Ashok, 2013). It is a small diffused, succulent, annual herb found throughout the tropical parts of India (Das *et al*., 2014). According to Kachare *et al.* (2005), *P. quadrifida* is a significant weed in maize (*Zea mays*) and onions (*Allium cepa*) in its native range of India. The Flora of China Editorial Committee (2015) reported that *P. quadrifida* has a negative economic impact on the crops that it is in association with, but no estimates of crop loss caused by the weed have been calculated. Chicken weed is sometimes used as a vegetable in Kenya and it is a plant that is usually found in dry sandy or rocky places with mat forming structure. The weed has been a nuisance to onion farmer's field at Birnin Kebbi. The weed has the ability to survive desiccation from small fragment of its stem, making it difficult to control. Streibig (2003) reported that Purslane, the genus which Chicken weed belongs is such a prolific seeder that once it has become established it is difficult to control. In view of the above it is important to employ the integrated weed management that will control chicken weed alongside other weed species for greater bulb size distribution of onion.

Ibrahim *et al*. (2011) reported that evidences have shown that farmers are using various ways to control weed, but their dependence is mainly hoe weeding. Cherati *et al*. (2011) reported that, in order to control weeds, there are different ways all over the world such as hand weeding methods, chemical weeding, mechanical weeding and a combination of them. Hand-weeding was the most important method for weed removal, but because of scarcity of agricultural workers, hand-weeding is not economical any more (Farooq *et al*., 2011). The objective of this study was to assess different plant population and weed management on the bulb size distribution of onion in North Western Nigeria

MATERIALS AND METHODS

Experimental site

This study was conducted on the Farmers field in Birnin Kebbi, Kebbi State during the 2017/2018 and 2018/2019 dry season to evaluate the effect of plant population and weed control methods on bulb size distribution of onion. Birnin Kebbi lies on latitude 12°25'N and longitude 4°15'E. Gindi *et al*. (2013) reported that Birnin Kebbi enjoys a tropical type of climate generally characterized by annual temperature range of 25-40°C with mean annual rainfall of about 500- 700 mm.

Treatment and experimental design

The treatments consisted of factorial combination of three plant population (500,000, 333,333, 250,000 plants/ha^{-1}) and twelve weed control treatments (pendimethalin @ 1.0 kg a.i. ha^{-1}: pendimethalin @ 1.5 kg a.i. ha^{-1}: pendimethalin @ 2.0 kg a.i. ha^{-1}: butachlor @ 2.0 kg a.i. ha^{-1}: butachlor @ 2.8 kg a.i. ha^{-1}: butachlor @ 3.6 kg a.i. ha^{-1}: fluaxifop-P-butyl @ 2.0 kg a.i. ha^{-1}: oxyfluorfen @ 1.0 kg a.i. ha^{-1}: weeding at 3 and 6 WAT: weeding at 3, 6 and 9 WAT: weed free and weedy check) and laid out in a Randomized Complete Block Design and replicated three times. The size of each plots was 2m × 3m and 1m pathways.

Nursery preparation

Nursery was established at the experimental field after the land was cleared of grasses and shrubs using cutlasses and hoes. The soil was manually tilled to a depth of 20-25 cm to produce a fine tilth. Two sunken beds were constructed measuring 1.2m x 6m and a mixture of organic manure and Single super phosphate fertilizer was incorporated in the nursery. The nursery was irrigated a day before onion seeds were sown by broadcasting method and mulching of the nursery beds was done with dry grasses. The nursery beds were irrigated daily in the evening from the time of broadcasting up to 1 week. There after irrigation was done at an interval of 3-5 days till they were ready for transplanting at 6 weeks after sowing.

Field establishment and management practices

The permanent site for the onion was cleared of shrubs, grasses and plant residues of previous cropping season using cutlasses and hoes. The land was wetted, manually tilled and levelled. The experimental layout was done based on number of treatments. Transplanting of onion was done at 6 weeks after sowing when the height of the seedlings was about 15-20cm. One seedling each was planted per hole at the depth of 3 cm following specification of plant population or spacing per plot (500,000, 333,333 and 250,000 plants/ha).

Fertilizer application, herbicide and irrigation

Organic manure at the rate of 4 t/ha was incorporated uniformly on each plots during construction. 120 kg NPK 15:15:15 fertilizer was applied at two split doses at 3 and 6 WAT, while application of herbicides was done* 2 days after transplanting (DAT) based on the treatment combination. The plots were irrigated at interval of 4 -5 days throughout the growing period.

Bulb size distribution of marketable bulbs

Weight of bulb size distribution of marketable bulbs according to Lemma and Shimeles (2003) were measured and recorded as small bulb size (20 - 50 g), medium (50 – 100 g), large (100 -160 g), and oversized (> 160g) was recorded per net plot and converted to kg ha^{-1}

Data collection and analysis

Data were collected at 3, 6 and 9 weeks after transplanting on growth, weed and bulb yield parameters. The data was subjected to analysis of variance (ANOVA) using statistical analysis software (SAS, 2002) and Duncan's Multiple Range Test was used for mean separation at 5% level of probability.

RESULTS

Soil analysis of the experimental field in 2017/18 and 2018/19 dry season indicated that the textural class of the soil was sandy loam with pH (in water) at 5.3 and 5.8 with strong acidic and moderately acidic in 2017/18 and 2018/19 dry seasons respectively. The soil in the experimental site was low in Total Nitrogen, Available P. including exchangeable cation (Ca, Mg, K and Na) were low. The cation exchange capacity (CEC) was low in both years, in 2018/2019 high CEC was observed.

Weed species that thrive alongside Chicken weed in 2017/2019 were identified base on their morphology thus; grasses (10), broad leaves (29) and sedges (4) and recorded, while in 2018/2019, grasses (7), broad leaves (23) and sedges (3) were recorded.

Effect of plant population and weed control treatments on small and medium bulb size

Table 1 presents the effect of plant population and weed control treatment on small and medium bulb size yield of onion at Birnin Kebbi during the 2017/2018 and 2018/2019 dry seasons and pooled data. The result showed that `plant population did not significantly ($p<0.05$) affect small and medium bulb size yield of onion in both years. Significant ($p<0.05$) difference on weed control treatments on small and medium size bulb yield was observed as presented in Table 1. The result obtained from small bulb size showed that the plots treated with pendimethalin at 1.0 Kg a.i. ha^{-1} significantly ($p<0.05$) produced the highest small bulb size yield in 2017/2018, similar trend was observed when pendimethalin at 2.0 Kg a.i. ha^{-1} was used. The result was at par with all weed control treatments except weedy check plot which produced the lowest small size bulb yield. In 2018/2019 dry season, plots with the weedy check and weeding at 3, 6 and 9 WAT significantly ($p<0.05$) produced the highest small size bulb yield. All other weed control treatments were at par, while the plots applied with fluazifop-p-butyl at the rate of 2.0 Kg a.i. ha^{-1} produced the lowest small size bulb yield. At pooled data, Plots treated with butachlor at the rate of 2.0 Kg a.i. ha^{-1} followed by one hoe weeding and weeding at 3, 6 and 9 WAT produced similar highest small bulb size and at par with all other weed control treatments (Table 1).

Medium size bulb yield as affected by weed control treatment at Birnin Kebbi during the 2017/2018 and 2018/2019 dry seasons and pooled data is presented was Table 1. In 2017/2018, weed control treatments showed significant ($p<0.05$) differences on medium size bulb yield such that the plots treated with pendimethalin at 1.0 Kg a.i. ha^{-1} followed by hoe weeding at 6 WAT significantly ($p<0.05$) produced the highest medium size bulb yield. The result was at par with the result obtained

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in plots treated with pendimethalin at 1.5 and 2.0 Kg a.i. ha^{-1} followed by the application of post emergence fluazifop-p-butyl at 2.0 Kg a.i. ha^{-1} and pendimethalin at 2.0 Kg a.i. ha^{-1} respectively, including fluazifop-p-butyl at 2.0 Kg a.i. ha^{-1} and oxyfluorfen at 1.0 Kg a.i. ha^{-1}. Medium size bulb obtained in weed free plots yield better than those recorded in plots treated with butachlor at 2.8 and 3.6 Kg a.i. ha^{-1}, weeding at 3, 6 and 9 WAT and weeding at 3 and 6 WAT. The lowest medium size bulb yield was recorded in weedy check plots. In 2018/2019 dry season, butachlor at the rate of 2.0 Kg a.i. ha^{-1} significantly ($p<0.05$) produced the highest medium size bulb yield. The result was at par with the result obtained in plots treated with pendimethalin at 1.5 Kg a.i. ha^{-1} followed by post emergence fluazifop-p-butyl at 2.0 Kg a.i. ha^{-1}, weeding at 3 and 6 WAT, weeding at 3, 6 and 9 WAT and weed free plots. Medium size bulb yield produced in plots with pendimethalin at 2.0 Kg a.i. ha^{-1}, butachlor at the rate of 2.8 and 3.6 Kg a.i. ha^{-1} and oxyfluorfen at 1.0 Kg a.i. ha^{-1} were higher than those recorded under plots treated with pendimethalin at 1.0 Kg a.i. ha^{-1} followed by one hoe weeding at 6 WAT and fluazifop-p-butyl at 2.0 kg a. ha^{-1}. The lowest medium size bulb yield was recorded under weedy check plots (Table 1). At pooled data, plots treated with butachlor at the rate of 2.0 Kg a.i. ha^{-1} followed by one hoe weeding recorded the highest medium size bulb yield, though at par with all plots treated with pendimethalin at 1.0, 1.5 and 2.0 Kg a.i. ha^{-1}, plots with fluazifop-p-butyl and oxyfluorfen and weeding three times. The lowest medium size bulb was recorded under the weedy check plots. Interaction of plant population and weed control treatment was observed on medium size bulb at pooled data (Table 1). Interaction of plant population and weed control treatments on medium size bulb at pooled data is presented in Table 2. The result showed that plots with plant population of 333,333 plants per hectare in combination with plots treated with pendimethalin at the rate of 1.5 Kg a.i. ha^{-1} followed by fluazifop-p-butyl at 2.0 Kg a.i. ha^{-1} significantly ($p<0.05$) produced the highest medium size onion bulb and it was at par with those result obtained in plots with plant population of 250,000 and 500,000 plants per hectare in combination with pendimethalin and butachlor at the rate of 1.0 and 2.0 Kg a.i. ha^{-1} followed by one hoe weeding respectively. The lowest medium size bulb was recorded in plots planted with plant population of 250,000 plants per hectare under weedy check. Similar lowest medium size bulb was recorded in plots planted with 333,333 plants per hectare in combination with plots applied with butachlor at the rate of 2.8 Kg a.i. ha^{-1} followed by post emergence application of oxyfluorfen at the rate of 1.0 Kg a.i. ha^{-1} (Table 2).

Effect of plant population and weed control treatments on large size bulb yield

Table 3 showed plant population and weed control treatment on large and over size bulb yield at Birnin Kebbi during the 2017/2018 and 2018/2019 dry seasons and pooled data. There was no significant ($p<0.05$) difference observed in plant population on large and over size bulb yield in both years. Significant ($p<0.05$) difference was revealed when putting weed control treatment in to consideration on large and over size bulb yield. In 2017/2018, weed control treatments affects large size bulbs significantly ($p<0.05$), such that the plots treated with pendimethalin at 1.0 Kg a.i. ha^{-1} followed by one hoe weeding at 6 WAT significantly ($p<0.05$) produced the highest large size bulb yield, while other remaining weed control treatment did not produce large size bulb yield. In 2018/2019 dry season, butachlor at the rate of 2.0 Kg a.i. ha^{-1} followed by one hoe weeding at 6 WAT produced the highest large size bulb yield. The result was at par with all other treatments except plots treated with butachlor at 2.8 Kg a.i. ha^{-1}, fluazifop-p-butyl at 2.0 kg a,i ha^{-1} and weedy check plots and recorded the lowest large size bulb yield. At pooled data, weed control treatments significantly ($p<0.05$) affects large size bulb in which plots treated with butachlor at the rate of 2.0 Kg a.i. ha^{-1} followed by one hoe weeding produced the highest large size bulbs and at par with all other weed control treatments except the plots treated with fluazifop-p-butyl at the rate of 2.0 Kg a.i. ha^{-1} which produced the lowest large size bulbs (Table 3). The result on over size bulb yield indicated that in 2017/2018 over

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size bulb was not visible in all the treatments evaluated. Likewise, in 2018/2019, there was no significant ($p<0.05$) differences observed in weed control treatments including at pooled data (Table 3).

DISCUSSION

The major weed flora that predominate onion in the experimental field during the study period were *Digitaria horizontalis*, *Paspalum scrobiculatum*, *Portulaca quadrifida*, *Portulaca oleraceae*, *Portulaca grandiflora*, *Trianthema portulacastrum*, *Acanthospermum hispidum*, *Gomphrena celosioides*, *Senna obtusifolia*, *Cleome gynandra*, *Cyperus esculentus*, and *Cyperus rotundus*. The broad leaf families were found to be more numerous compared with grasses and sedges. Bulb size distribution of onion such as small, medium, large and over size bulb yield was not significantly influenced subjected to plant population treatments in this study. The non significant ($p<0.05$) difference among plant population treatments on bulb size distribution of onion might be as a result of less weed emergence accompanied with uniform application of NPK 15:15:15 fertilizer and irrigation coupled with existing conducive environmental condition in the study area. The result is similar to the work of Ahmed and Abdulrhim (2010) on the effect of plant density and Cultivar on growth and yield of Cowpea which revealed that plant population had no significant effect on number of seeds per pod in both seasons. With the evaluation of weed control treatments on bulb size distribution, small, medium and large size bulb yield were significantly ($p<0.05$) affected. In 2017/2018 trial, control of chicken weed alongside other weed species using pendimethalin at 1.0 kg a.i. ha^{-1} at planting followed by one hoe weeding at 6 WAT recorded the highest bulb size distribution on small, medium and large size bulb yield, though butachlor at the rate of 2.0 kg a.i. ha^{-1} supplemented with one hoe weeding in 2018/2019 followed similar trend and also at pooled data. This is an indication that integration of more than one weed control methods gives better control of existing weed species in a particular area. This is in agreement with the results of Ramalingam *et al*. (2013) who reported that higher bulb yield attributes were recorded with the pre-emergence application of pendimethalin at 0.75 kg·ha−1 + HW on 45 DAS. It was also reported that, the common weed management practice for onion is pre-emergence application of selective herbicides like pendimethalin among other selective pre-emergence herbicides followed by one hand weeding (Ramalingam *et al*., 2013). Even Hussain *et al*. (2008) testified that pendimethalin plus hand weeded treatments were the most effective in weed control and onion yield. Likewise, small bulb size was influenced by hoe weeding at 3, 6 and 9 WAT and similarly at pooled data in 2018/2019. Hand weeding at interval of 3 weeks throughout production period reduces weed impact and increase yield of any crop. The work of Zubair *et al*. (2009) on the comparison of weed management practices in onion indicated that hand weeding at interval throughout the growing period had controlled all weeds, this practice resulted in the highest onion bulb yield, but this practice is laborious and not economical for subsistence farmers in the control of weeds compared to the application of herbicides.

Observation on interaction of plant population and weed control treatments on medium size bulb yield revealed that plant population of 333,333 plants/ha in combination with application of pendimethalin at 1.5 kg a.i ha^{-1} supplemented with fluazifop-p-butyl at 2.0 Kg a.i. ha^{-1} recorded the highest medium size bulb yield, while the lowest medium size bulb was recorded in the weedy check plot. Pre-emergence followed by post-emergence herbicides play a greater role as an integrated weed management strategy. Over sized onion bulb was not significantly ($p<0.05$) affected with weed control treatments, but numerically, the highest value (110.30) for over sized onion bulb was recorded with the use of pendimethalin at 1.0 Kg a.i. ha^{-1}.

CONCLUSION

Results of the current study revealed that application of pendimethalin and butachlor at the rate of 1.0 and 2.0 Kg a.i. ha^{-1} followed by one hoe weeding respectively was superior compare to other weed control treatments and thus can be recommended for bulb size distribution of onion in Birnin Kebbi, Nigeria. Weeding at 3, 6 and 9 weeks interval could be an alternative to the aforementioned practice.

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Table 1. Effect of plant population and weed control treatments on small and Medium size bulb yield at Birnin Kebbi during the 2017/2018 and 2018/2019 dry seasons

Treatment	Rate (kg a.i. ha^{-1})	Small size bulb yield			Medium size bulb yield		
		2017/ 2018	2018/ 2019	Pooled	2017/ 2018	2018/ 2019	Pooled
Plant population							
500,000		87.86	96.94	92.38	84.30	148.97	116.64
333,333		91.12	100.32	95.72	91.48	151.04	121.26
250,000		91.30	100.78	96.05	105.80	143.67	124.73
SE±		3.36	3.84	2.31	10.05	11.99	7.23
Weed control methods							
Pendimethalin	1.0 fb 1 HW	103.13^{a}	93.43^{ab}	98.28^{ab}	148.25^{a}	107.12^{d}	127.69^{abc}
Pendimethalin fb Fluazifop-p-butyl	1.5 fb 2.0	88.23^{ab}	102.57^{ab}	95.40^{ab}	129.74^{ab}	191.02^{ab}	160.38^{ab}
Pendimethalin	2.0	100.23^{a}	93.41^{ab}	96.83^{ab}	119.15^{abc}	130.72^{bcd}	124.93^{abc}
Butachlor	1.0 fb 1 HW	95.32^{ab}	108.04^{ab}	101.68^{a}	123.01^{abc}	208.97^{a}	165.99^{a}
Butachlor fb Oxyfluorfen	2.8 fb 1.0	86.83^{abc}	96.43^{ab}	91.63^{ab}	84.05^{bcd}	129.14^{bcd}	106.59^{c}
Butachlor	3.6	90.79^{ab}	98.06^{ab}	94.43^{ab}	78.10^{bcd}	136.67^{bcd}	107.39^{c}
Fluazifop-p-butyl	2.0	85.08^{ab}	86.61^{b}	85.85^{b}	118.75^{abc}	122.96^{cd}	120.85^{abc}
Oxyfluorfen	1.0 fb 1 HW	88.01^{ab}	94.39^{ab}	91.21^{ab}	103.51^{a-d}	139.31^{bcd}	121.41^{abc}
Hoe weeding	3 and 6WAT	87.26^{ab}	93.95^{ab}	90.61^{ab}	57.74^{de}	146.37^{a-d}	102.06^{cd}
Hoe weeding	3, 6 and 9 WAT	91.30^{ab}	114.86^{a}	103.08^{a}	80.76^{bcd}	176.72^{abc}	133.24^{abc}
Weed free		86.44^{ab}	99.64^{ab}	93.04^{ab}	67.89^{cd}	168.52^{a-d}	118.21^{bc}
Weedy check		78.30^{b}	110.81^{a}	94.56^{ab}	6.38^{e}	117.15^{cd}	61.77^{d}
SE±		6.73	7.69	4.62	20.11	23.98	14.46
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,

Table 2. Interaction of plant population and weed control treatments on medium size bulb yield at pooled data at Birnin Kebbi.

Weed control methods	Rate (kg a.i. ha^{-1})	Plant population (plants/ha^{-1}) 500,000	333,333	250,000
Pendimethalin	1.0 fb 1 HW	82.88^{opq}	122.0^{g-m}	178.2^{abc}
Pendimethalin fb Fluazifop-p-butyl	1.5 fb 2.0	170.2^{bcd}	198.9^{a}	112.1^{i-n}
Pendimethalin	2.0	75.48^{q}	141.2^{efg}	158.1^{cde}
Butachlor	1.0 fb 1 HW	186.9^{ab}	153.1^{def}	158.1^{cde}
Butachlor fb Oxyfluorfen	2.8 fb 1.0	141.5^{d-g}	42.97^{s}	135.3^{e-j}
Butachlor	3.6	78.60^{pq}	109.6^{k-n}	134.0^{e-k}
Fluazifop-p-butyl	2.0	113.4^{i-n}	142.1^{efg}	107.11^{mno}
Oxyfluorfen	1.0 fb 1 HW	110.9^{i-n}	129.5^{f-l}	123.9^{g-m}
Hoe weeding	3 and 6WAT	96.55^{n-q}	94.61^{n-q}	115.0^{h-n}
Hoe weeding	3, 6 and 9 WAT	136.6^{e-i}	140.0^{e-h}	123.1^{g-m}
Weed free	-	102.6^{m-p}	134.9^{e-j}	117.1^{g-n}
Weedy check	-	104.1^{mno}	46.27^{rs}	34.96^{s}
SE±			25.05	

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).

Table 3. Effect of plant population and weed control treatments on large and over size bulb yield at Birnin Kebbi during the 2017/2018 and 2018/2019 dry seasons

Treatment	Rate (kg a.i. ha^{-1})	Large size bulb yield 2017/ 2018	2018/ 2019	Pooled	Over size bulb yield 2017/ 2018	2018/ 2019	Pooled
Plant population							
500,000		0.00	115.70	57.85	0.00	66.89	33.44
333,333		8.64	113.05	60.85	0.00	41.21	20.61
250,000		9.78	92.99	51.39	0.00	32.34	16.17
SE±		4.25	20.47	10.1	0.00	20.90	9.8
Weed control methods							
Pendimethalin	1.0 fb 1 HW	66.09^{a}	114.08^{ab}	90.08^{ab}	0.00	110.30	55.15
Pendimethalin fb Fluazifop-p-butyl	1.5 fb 2.0	0.00^{b}	135.49^{ab}	67.74^{abc}	0.00	53.12	26.56
Pendimethalin	2.0	0.00^{b}	95.20^{ab}	47.60^{abc}	0.00	32.87	16.39
Butachlor	2.0 fb 1 HW	0.00^{b}	198.49^{a}	99.24^{a}	0.00	101.58	50.79
Butachlor fb Oxyfluorfen	2.8 fb 1.0	0.00^{b}	60.98^{b}	30.47^{bc}	0.00	36.31	18.16
Butachlor	3.6	7.62^{b}	83.61^{ab}	45.62^{abc}	0.00	12.57	0.00
Fluazifop-p-butyl	2.0	0.00^{b}	44.10^{b}	22.05^{c}	0.00	0.00	0.00
Oxyfluorfen	1.0 fb 1 HW	0.00^{b}	86.41^{ab}	43.21^{abc}	0.00	20.48	10.24
Hoe weeding	3 and 6WAT	0.00^{b}	122.03^{ab}	61.01^{abc}	0.00	23.40	11.70
Hoe weeding	3, 6 and 9 WAT	0.00^{b}	130.76^{ab}	65.38^{abc}	0.00	82.49	41.24
Weed free		0.00^{b}	141.48^{ab}	70.74^{abc}	0.00	88.75	44.37
Weedy check		0.00^{b}	74.37^{b}	37.19^{abc}	0.00	0.00	6.28
SE±		8.50	40.95	20.20	0.00	41.81	19.60
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,