EVALUAION OF PLANT POPULATION AND WEED CONTROL TREATMENTS ON THE MANAGEMEN OF WEEDS IN ONION (*Allium cepa* L.) FIELD

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SUMMARY

Field trials were conducted in Birnin kebbi, Nigeria during the 2017/2018 and 2018/2019 dry seasons to evaluate the effect of plant population and weed control methods on the management of weeds in Onion field. The experiment consisted of three plant population (500,000, 333,333 and 250,000 plants/ha) and weed control treatments (Pre-emergence application of pendimethalin (1.0, 1.5 and 2.0 kg a.i. ha^{-1}), butachlor (2.0, 2.8 and 3.6 kg a.i. ha^{-1}), post-emergence application of fluaxifop-P-butyl at 2.0 kg a.i. ha^{-1}, oxyfluorfen at 1.0 kg a.i. ha^{-1}, weeding at 3, 3 and 6 WAT, weed free and weedy check making a total of 36 treatments. It was laid out in Randomized Complete Block Design replicated three times. Results showed that plant population of 500,000 plants/ha gave higher plant stand count and 333,333 plants/ha recorded the highest weed control efficiency. All weed treatments contributed to weed control, but higher plant stand count and taller plants were obtained with pendimethalin at 1.0 kg a.i. ha^{-1}. Weedy check and plots that received application of fluaxifop-P-butyl at 2.0 kg a.i. ha^{-1} recorded the highest crop injury, weed density and lowest weed control efficiency, while the highest weed control efficiency was recorded with butachlor at 2.0 kg a.i. ha^{-1}. Pendimethalin and butachlor at 1.0 and 2.0 kg a.i. ha^{-1} respectively produced similar highest fresh onion bulb yield, while hoe weeding at 3 and 6 WAT and butachlor at 2.0 kg a.i. ha^{-1} recorded the highest unmarketable bulb yield. From the results, application of pendimethalin and butachlor at the rate of 1.0 and 2.0 kg a.i. ha^{-1} are more suitable for the control of weed in onion field.

Keywords: Onion, weed, population, herbicide, density, efficiency

ONION (*Allium cepa* L.) is a vegetable crop grown almost all over the world. According to (Grema and Gashua, 2014) the relatively poor performance of onion production in the country is constrained by a number of factors such as soil, pant disease, unfavourable climate and weeds. Among these factors, weed control is most important as it has been reported to be responsible for between 70 and 89% losses in the bulb of onions. Weeds are important impediment to crop production because they are omnipresent and reduce crop yields. Weeds differ from other plants in being more aggressive, having peculiar characteristics that make them more competitive. Weeds decrease crop yield by competing for environmental resources such as water, nutrients, space, air and light and the release of allelochemicals in the rhizosphere through the roots and some other plant parts (Reddy, 2012). However, Clarence *et al.* (2015) reported that the annual global economic loss caused by weeds has been estimated at more than $100 billion U.S. dollars, while an estimated 30 – 45 % of the total cost of manual weeding has been reported from fruits and vegetable production in Nigeria (Chianu and Akintola, 2003). Take-tsaba *et al.* (2011) also reported that the nuisance caused by weeds is a top most problem interfering with farming activities in the Sudan savannah zone of Nigeria where yield losses from weedy control plots are estimated to range from 20 to 60% in Sesame.

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. With favourable conditions of sufficient soil moisture and nutrients, higher plant population is necessary to utilize all growth factors efficiently. The level of plant population should be such that maximum solar radiation is utilized. Transplanting density, along with other factors, has been investigated in several studies with onion (Boyban *et al*., 2009). It has been reported by Yakubu (2000) that the density effect, frequency impact, timeliness of weeding and chemical weed control methods, herbicides use and application all pose great limitations to farmers.

Manual weeding, from time immemorial has being efficient in weed control, but it has now been restricted due to several economic and technological factors (Khaliq and Matloob, 2011a). Degree of competition offered by a crop can influence the herbicide performance (Khaliq and Matloob, 2011b). Different herbicide have been formulated, screened and found effective for pre-emergence and post-emergence weed control in crops. Chemical weed control by pre-sowing, pre-emergence, early post-emergence and combinations of them are all effective for weed control (Sureshkumar *et al*., 2016). Thus use of herbicides is one of the options left with the farmers to eliminate crop weed competition at early growth stage of crop. The objective of this study was therefore to evaluate plant population and different weed control treatments for the control of weeds in onion.

MATERIALS AND METHODS

Field study was conducted on Farmers' fields in Birnin Kebbi, Kebbi State during the dry seasons of 2017/2018 and 2018/2019 to evaluate the effect of plant population and weed control methods on weeds in Onion field. Birnin Kebbi enjoys annual temperature between 25 and 40^{0C}. To ascertain the nutrient composition of the soil in the experimental field, composite soil samples were collected across the field and were analyzed for its physical and chemical properties. The treatments consisted of factorial combination of three plant population (500,000, 333,333, 250,000 plants/ha^{-1}) and twelve weed control treatments (1. pendimethalin at 1.0 kg a.i. ha^{-1}, 2. pendimethalin at 1.5 kg a.i. ha^{-1}, 3. pendimethalin at 2.0 kg a.i. ha^{-1}, 4. butachlor at 2.0 kg a.i. ha^{-1}, 5. butachlor at 2.8 kg a.i. ha^{-1}, 6. butachlor at 3.6 kg a.i. ha^{-1}, 7. fluaxifop-P-butyl at 2.0 kg a.i. ha^{-1}, 8. oxyfluorfen at 1.0 kg a.i. ha^{-1}, 9. hoe weeding (hw) at 3 weeks after transplanting (WAT), 10. hoe weeding at 3 and 6 WAT, 11. Weed free, 12. Weedy check) laid down in a Randomized Complete Block Design and replicated three times. The field was wetted, manually ploughed and plot size of 2m × 3m was constructed. Organic manure at the rate of 4 t/ha was incorporated uniformly on each plots during construction and application of herbicides was applied 2 days after transplanting (DAT) based on the treatment combination. 120 kg NPK fertilizer was applied at two split doses at 3 and 6 WAT. The plots were irrigated 4 -5 days throughout the growing period. At 3 and 6 WAT, data were collected on plant stand count, plant height, leaf area, crop injury score, weed density, weed control efficiency, fresh bulb yield and unmarketable bulb yield. The data was subjected to analysis of variance (ANOVA) using statistical analysis software (14) at 5% level of probability.

RESULTS

Effect of Plant population and Weed control Treatments on Growth parameters of Onion in Birnin Kebbi

Growth parameters of Onion such as plant stand count, plant height and leaf area as affected by Plant population and Weed control treatments at 6 WAT in 2017/2018 and 2018/2019 are presented in Table 1. The results showed that plant height and leaf area in both years were not significantly affected by plant population, but plant stand count was affected by plant population in 2018/2019 of which 500,000 plants/ha^{-1} produced the highest number of plants per hectare and plots with 250,000 plants/ha^{-1} produced the lowest number of stand but was at statistically at par with 333,333 plants/ha.

Considering the weed control treatments, the use of Pendimethalin at 1.0 kg a.i. ha^{-1} at 2 DAT in both years consistently suppress the weeds to produce the highest number of plant stands, though similar highest number of stand count were observed in 2017/18 with the application ob pendimethalin at 1.5 kg a.i. ha^{-1} followed by fluaxifop-P-butyl at 2.0 kg a.i. ha^{-1}, oxyflourfen at 1.0 kg a.i. ha^{-1} followed by one hoe weeding, hoe weeding at 3 WAT, weeding at 3 and 6 WAT including weed free plots in 2018/19. Application of fluaxifop-P-butyl at 2.0 kg a.i. ha^{-1} in 2017/18 and butachlor at the rate of 3.6 kg a.i. ha^{-1} recorded the lowest stand count. Significant ($p<0.05$) increase in plant height was observed when pendimethalin at 1.0 kg a.i. ha^{-1} followed by one hoe weeding was used in both years, though similar increase in plant height was observed in 2018/19 with the application of pendimethalin at 1.5 kg a.i. ha^{-1} followed by fluaxifo-P-butyl at 2.0 kg a.i. ha^{-1}. Shorter plants compared with other weed control treatments were noticed in the use of butachlor at 2.8 kg a.i. ha^{-1} in both years.

The use of pendimethalin at 1.5 kg a.i. ha^{-1} followed by one hoe weeding in 2017/18 and pendimethalin at 2.0 kg a.i. ha^{-1} alone gave significantly larger leaf area. Smaller leaf area of onion was noticed with the use of butachlor at 2.8 kg a.i. ha^{-1}, though in 2017/18 application of fluaxifop-

P-butyl at 2.0 kg a.i. ha^{-1}, weed free and weedy check plots also recorded smaller leaf area in this study.

Table 1: Effect of plant population and weed control treatments on growth parameters of Onion 6 WAT in Birnin Kebbi, Kebbi State

Treatment	Rate (kg a.i. ha^{-1})	Plant stand count		Plant height		Leaf area	
		2017-2018	2018-2019	2017-2018	2018-2019	2017-2018	2018-2019
Plant population (kg ha^{-1})							
500,000		98.99	99.23a	26.04	28.11	2928.3	3075.1
333,333		98.33	99.06ab	26.71	27.76	2926.8	3058.3
250,000		98.01	98.75b	25.83	27.65	2810.7	3019.8
SE±		0.19	0.15	0.75	1.01	79.90	113.14
Weed Control (WC)							
Pendimethalin	1.0 fb 1HW	98.50a	99.80a	31.98a	33.29a	3152.3abc	3073.9a-d
Pendimethalin fb Fluazifop-p-butyl	1.5 fb 2.0	98.60a	99.06abc	29.89ab	32.97a	3525.5a	3623.2ab
Pendimethalin	2.0	98.12ab	98.66bc	28.78abc	28.39abc	3287.9ab	3668.5a
Butachlor	2.0 fb 1HW	98.23ab	99.23ab	29.11abc	31.52ab	3208.6abc	3474.2abc
Butachlor fb Oxyfluorfen	2.8 fb 1.0	97.57ab	98.54bc	21.56e	22.18d	2517.6d	2445.4e
Butachlor	3.6	97.96ab	98.37c	25.16cde	25.57cd	2773.9cd	2722.2de
Fluazifop-p-butyl	2.0	97.27b	98.96abc	23.82ed	25.60cd	2598.2d	2821.6de
Oxyfluorfen	1.0	98.55a	99.01abc	26.08bcd	27.76a-d	2844.6bcd	3059.5a-e
Hoe weeding	3 WAT	98.49a	99.25ab	25.68cde	28.06abc	2830.9cd	3094.0a-d
Hoe weeding	3 and 6WAT	98.45a	98.98abc	25.70bcd	27.00bcd	2832.4cd	2975.7cde
Weed - free		98.03ab	99.59a	23.40de	27.89a-d	2578.4d	2628.1de
Weedy check		97.55ab	98.66bc	23.16de	23.84cd	2513.0d	3026.2b-e
SE±		0.39	0.30	1.51	2.02	159.81	226.29
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, WAT= weeks after transplanting, fb = follow by, HW= hoe weeding

Effect of plant population and weed control on crop injury and weed parameters of Onion in Birnin Kebbi

Crop injury score and weed parameters such as weed density and weed control efficiency (WCE) as affected by plant population and weed control in 2017/2018 and 2018/2019 is presented in Table 2. Results showed that crop injury and weed density in both years and weed control efficiency in 2017/2018 were not affected by plant population, but significant differences was observed on WCE in 2018/2019 of which plant population of 333,333 plants/ha^{-1} recorded the highest WCE, though, at par with the records obtained from plots with plant population of 500,000 plants/ha, while the lowest WCE was obtained under 250,000 plant/ha^{-1}.

Weed control treatments effectively acted significantly to record the highest crop injury when fluaxifop-P-butyl at 2.0 kg a.i. ha^{-1} and weedy check plots were observed in both years. Similar highest crop injury was noticed in plots sprayed with butachlor at the rate of 2,8 kg a.i. ha^{-1}. The lowest crop injury score among other weed control treatments was recorded in plots applied with pendimethalin at 1.0 and 2.0 kg a.i. ha^{-1} 2 DAT in 2017/2018 and 2018/2019 respectively. Significant reduction in weed density was recorded under plots sprayed with all rates of pre emergence application of pendimethalin and Butachlor including weed free plots in both years except that plots with pre emergence application of pendimethalin at 1.5 kg a.i. ha^{-1} and butachlor at 3.6 kg a.i. ha^{-1} recorded increased weed density compared with other plots with pre emergence application treatments. The highest weed density was recorded in plots with weedy check. Interaction of the factors on weed density was observed in 2018/19 as presented in Table 2 and the results presented in Table 3 showed that significant reduction of weed density was revealed in plots planted with 33,333 plants/ha in combination with butachlor at 2.8 kg a.i. ha^{-1}, while the highest weed density was noticed in the weedy check plots under plant population of 33,333 plants/ha.

The bioactivity of pre-emergence of pendimethalin and butachlor applied at all rates including the weed free plots in 2018/19 significantly ($p<0.05$) recorded highest weed control efficiency. But in 2017/18 application of butachlor at 2.0 kg a.i. ha^{-1} gave the highest weed control efficiency, though at par with other weed control treatments except application of fluaxifop-P-butyl at 2.0 kg a.i. ha^{-1}, oxyflourfen at 1.0 kg a.i. ha^{-1}, hoe weeding at 3 WAT, weeding at 3 and 6 WAT and weedy check which recorded the lowest weed control efficiency (Table 2). Interaction of factors on weed control efficiency was observed ant the result as presented in Table 4 showed that the highest weed control efficiency was recorded in plots with 333, 333 plants/ha in combination with butachlor at 2.0 kg a.i. ha^{-1}. The lowest weed control efficiency was recorded in all the plant population studied in combination with weedy check (Table 4).

Table 2: Effect of plant population and weed control treatments on weed parameters of Onion in Birnin Kebbi, Kebbi State

Treatments	Rate (kg a.i. ha^{-1})	Crop injury score		Weed density		Weed control efficiency	
		2017-2018	2018-2019	2017-2018	2018-2019	2017-2018	2018-2019
Plant population (kg ha^{-1})							
500,000		9.58	10.69	19.91	17.75	72.89	81.99ab
333,333		10.13	11.11	19.13	17.00	74.13	84.70a
250,000		9.86	11.94	18.22	17.08	69.37	81.19b
SE±		0.46	0.60	1.40	1.20	1.75	1.03
Weed Control (WC)							
Pendimethalin	1.0 fb 1HW	6.67d	11.11a-d	10.56e	4.33c	84.33ab	95.91a
Pendimethalin fb Fluazifop-p-butyl	1.5 fb 2.0	8.33cd	9.44bcd	15.00cde	4.56c	78.44abc	95.89a
Pendimethalin	2.0	8.33cd	8.33d	11.22e	3.11c	83.57ab	96.46a
Butachlor	2.0 fb 1HW	8.89cd	8.89cd	9.89e	2.89c	85.92a	96.86a
Butachlor fb Oxyfluorfen	2.8 fb 1.0	12.22ab	13.89a	10.33e	7.89c	84.98ab	91.62a
Butachlor	3.6	10.55abc	11.11a-d	11.67de	2.78c	82.95ab	97.33a
Fluazifop-p-butyl	2.0	12.78a	13.89a	19.33bcd	20.67b	71.65cd	78.69b
Oxyfluorfen	1.0	8.89cd	12.22abc	16.11b-e	19.00b	75.30bc	80.98b
Hoe weeding	3 WAT	9.44c	9.44bcd	23.89b	20.44b	62.78d	79.08b
Hoe weeding	3 and 6WAT	9.44c	10.55a-d	21.67bc	17.00b	70.64cd	82.41b
Weed - free		10.00bc	12.78ab	10.33e	3.89c	84.99ab	96.26a
Weedy check		12.78a	13.33a	69.11a	100.78a	0.00e	0.00e
SE±		0.92	1.21	2.80	2.41	3.51	2.06
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, WAT= weeks after transplanting, fb = follow by, HW= hoe weeding

Table 3: Interaction of plant population and weed control treatments on weed density in Birnin Kebbi 6 WAT during 2018/2019 dry season.

Weed control	Rate (kg a.i. ha^{-1})	Plant population		
		500,000	333,333	250,000
Pendimethalin	1.0 fb 1HW	1.67lmn	9.67ij	1.67lmn
Pendimethalin fb Fluazifop-p-butyl	1.5 fb 2.0	10.33hi	2.67k-n	0.67mn
Pendimethalin	2.0	3.00k-n	3.33k-n	3.00k-n
Butachlor	2.0 fb 1HW	4.33klm	0.00n	4.33klm
Butachlor fb Oxyfluorfen	2.8 fb 1.0	4.67klm	12.67hi	6.33jk
Butachlor	3.6	3.67k-n	3.33k-n	1.33lmn
Fluazifop-p-butyl	2.0	18.67fg	14.67gh	28.67d
Oxyfluorfen	1.0	27.33de	12.67hi	17.00fg
Hoe weeding	3 WAT	14.33gh	19.00f	28.00d
Hoe weeding	3 and 6WAT	23.33e	9.67ij	18.00fg
Weed - free		2.33k-n	5.33kl	4.00k-n
Weedy check		99.33b	111.00a	92.00c
SE±			4.18	

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). WAT= weeks after transplanting, fb = follow by, HW= hoe weeding

Table 4: Interaction of plant population and weed control treatments on weed control efficiency in Birnin Kebbi 6 WAT during 2018/2019 dry season.

Weed control	Rate	Plant population		
	(kg a.i. ha^{-1})	500,000	333,333	250,000
Pendimethalin	1.0 fb 1HW	98.09abc	91.39d	98.26abc
Pendimethalin fb Fluazifop-p-butyl	1.5 fb 2.0	90.75d	97.62abc	99.31ab
Pendimethalin	2.0	97.26abc	96.98abc	95.15c
Butachlor	2.0 fb 1HW	95.30c	100.00a	95.30c
Butachlor fb Oxyfluorfen	2.8 fb 1.0	94.62cd	88.74de	91.52cd
Butachlor	3.6	96.38bc	97.02abc	98.61abc
Fluazifop-p-butyl	2.0	80.40g	86.60ef	69.09j
Oxyfluorfen	1.0	73.11hi	88.50de	81.32fg
Hoe weeding	3 WAT	84.52f	82.96fg	69.78ij
Hoe weeding	3 and 6WAT	75.48h	91.40d	80.36g
Weed - free		97.97abc	95.19c	95.64c
Weedy check		0.00k	0.00k	0.00k
SE±			3.57	

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). WAT= weeks after transplanting, fb = follow by, HW= hoe weeding

Effect of Plant population and Weed Control Treatments on Yield parameters of Onion in Birnin Kebbi

Yield parameters as affected by plant population and weed control treatments is presented in Table 5. The result showed that plant population did not significantly ($p<0.05$) did not affect fresh bulb and unmarketable bulb yield in both years of the experimentation.

Weed control treatments significantly ($p<0.05$) affects fresh bulb and unmarketable bulb yield such that plots sprayed with pendimethalin at the rate of 1.0 kg a.i. ha and butachlor at the rate of 2.0 kg a.i. ha^{-1} statistically recorded similar highest fresh bulb yield in 2017/2018 and 2018/2019 respectively, though the result were at par with those result obtained in 2017/18 with pendimethalin at 1.5 kg a.i. ha^{-1}, butachlor at 2.0 kg a.i. ha^{-1} and hoe weeding at 3 and 6 WAT, while in 2018/19 results were at par with all the treatments except plots with the application of fluaxifop-P-butyl at 2.0 kg a.i. ha^{-1} and weedy check in 2017/18 which recorded the lowest fresh bulb yield.

The use of hoe weeding at 3 WAT and application of butachlor at the rate of 2.0 kg a.i. ha^{-1} recorded the highest Unmarketable bulb yield in 2017/18 and 2018/19 respectively, though in 2017/18 results were at par with all rates of pendimethalin, fluaxifop-P-butyl at 2.0 kg a.i. ha^{-1}, weeding at 3 WAT and weeding at 3 and 6 WAT, while in 2018/19 all the treatments were at par except pendimethalin at 1.0 kg a.i. ha^{-1} which recorded the lowest unmarketable bulb yield which was the same with all the rates of butachlor, oxyflourfen at 1.0 kg a.i. ha^{-1} and weedy check in 2017/18. Interaction of plant population and weed control methods was noticed on Unmarketable bulb yield in 2017/2018 (Table 5). The result as presented in Table 6 showed that plant population of 250,000 plants/ha^{-1} and the use of hoe weeding at 3 and 6 WAT recorded the highest unmarketable bulb yield, while the lowest unmarketable bulb yield was obtained in the plots sprayed with butachlor at 2.0 kg a.i. ha^{-1} under plant population of 250,000 plants/ha.

Table 5: Effect of plant population and weed control treatments on Yield parametersof Onion in Birnin Kebbi, Kebbi State

Treatments	Rate	Fresh bulb yield		Unmarketable bulb yield	
	(kg a.i. ha^{-1})	2017-2018	2018-2019	2017-2018	2018-2019
Plant population ($kg\ ha^{-1}$)					
500,000		790.89	1165.12	41.34	41.25
333,333		775.56	1250.00	41.49	41.75
250,000		7712.6	1162.03	43.52	39.67
SE±		44.43	107.08	2.06	0.98
Weed Control (WC)					
Pendimethalin	1.0 fb 1HW	1080.2a	1435.2ab	43.93ab	38.34b
Pendimethalin fb	1.5 fb 2.0	925.9abc	1388.9abc	43.67ab	38.85ab
Pendimethalin	2.0	817.9b-e	1095.7abc	42.47ab	39.35ab
Butachlor	2.0 fb 1HW	987.7ab	1512.3a	40.02b	44.21a
Butachlor fb Oxyfluorfen	2.8 fb 1.0	617.3de	1095.7abc	39.76b	41.98ab
Butachlor	3.6	709.9cde	833.3bc	39.85b	42.02ab
Fluazifop-p-butyl	2.0	817.9b-e	790.1c	40.36ab	39.08ab
Oxyfluorfen	1.0	663.6de	941.4abc	39.93b	38.89ab
Hoe weeding	3 WAT	586.4e	1172.8abc	51.85a	40.72ab
Hoe weeding	3 and 6WAT	848.8a-d	1404.3ab	45.18ab	42.56ab
Weed free		725.3cde	1373.5abc	41.23ab	42.78ab
Weedy check		571.0e	1265.4abc	37.16.b	42.00ab
SE±		88.87	214.17	4.12	1.96
Interaction					
PP*WC		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, WAT= weeks after transplanting, fb = follow by, HW= hoe weeding

Table 6: Interaction of plant population and weed control treatments on unmarketable bulb yield in Birnin Kebbi during 2017/2018 dry season.

Weed control treatment	Rate (kg a.i. ha^{-1})	Plant population		
		500,000	333,333	250,000
Pendimethalin	1.0 fb 1HW	40.80d-l	47.39cd	43.61d-i
Pendimethalin fb Fluazifop-p-butyl	1.5 fb 2.0	43.17d-j	46.07de	41.74d-l
Pendimethalin	2.0	42.76d-k	44.39d-g	40.28de-l
Butachlor	2.0 fb 1HW	44.63def	44.20d-h	31.25m
Butachlor fb Oxyfluorfen	2.8 fb 1.0	37.35g-m	36.13klm	45.80de
Butachlor	3.6	41.95d-l	36.92i-m	40.69d-l
Fluazifop-p-butyl	2.0	42.85d-k	41.46d-l	36.78i-m
Oxyfluorfen	1.0	39.39e-l	40.21e-l	40.22e-l
Hoe weeding	3 WAT	35.35lm	36.18j-m	84.02a
Hoe weeding	3 and 6WAT	54.11bc	40.74de-l	40.71d-l
Weed - free		37.09h-m	45.69def	40.93d-l
Weedy check		36.67i-m	38.58f-l	36.26j-m
SE±			7.15	

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). WAT= weeks after transplanting, fb = follow by, HW= hoe weeding

DISCUSSION

Plant population effects in terms of plant height, leaf area, crop injury, weed density, fresh bulb yield and unmarketable bulb yield were not statistically significant in this study, though, plant population effects on plant stand count and weed control efficiency showed that plant population of 500,000 plants/ha^{-1} was good for better survival of onion stands. The work of Uwah *et al*. (2014) on poultry manure and plant population on agronomic performance of maize showed that plant population has no significant ($p<0.05$) effect on plant height, number of leaves and leaf area. Likewise, weed control efficiency under plant population of 333,333 plants/ha was observed very effective for weed suppression, though at par with plant population of 500,000 plants/ha.

Weed control treatments have played greater role in the control of weeds in onion during the field study. Higher plant stand count and taller plants were achieved through the use of Pre-emergence application of pendimethalin at 1.0 kg a.i. ha^{-1}, though similar higher plant stand count was recorded with the use of oxyfluorfen at 1.0 kg a.i. ha^{-1}, hoe weeding and weed free. Application of pendimethalin at 1.5 kg a.i. ha^{-1} supplemented with fluaxifop-P-butyl at 2.0 kg a.i. ha^{-1} and pendimethalin at 2.0 kg a.i. ha^{-1} produced the highest leaf area. This indicates that supplementing pre emergence with post-emergence herbicide will go a long way in reducing weed free condition. The use of pendimethalin as pre-emergence and oxyfluorfen as post-emergence was reported by Kalhapure *et al.* (2013) to be responsible for better growth and development of onion. Highest crop injury was consistently observed with the use of fluaxifop-P-butyl at 2.0 kg a.i. ha^{-1} and weedy check plots. The highest crop injury observed might be due to toxic effect of herbicide rate used on the crop. Similar report was cited by Mahadi *et al.* (2016) who reported that crop injury could be due to phytotoxicity of the treatment on sorghum particularly at the rate applied. Weedy check significantly ($p<0.05$) recorded the highest weed density, while lowest weed density resulted from the use of weed free plots which was similar to result obtained from the use of all rates of pre-emergence application of pendimethalin and butachlor. Similar result was obtained in the work of Hussain *et al*. (2008) who indicates that the highest weed density was recorded in the weedy check while the lowest weed density was recorded in the hand weeded treatment followed by pendimethalin. Highest weed control efficiency was obtained with the use of butachlor at 2.0 kg a.i. ha^{-1}, even though all the levels of pre emergence application of pendimethalin and butachlor recorded similar highest weed control efficiency in the second year of this trial including weed free plots. Similar results have been obtained by Singh *et al*. (2017) who stated that highest Weed control efficiency (85%) was revealed in weed free treatment and was statistically at par with herbicide treatments. The lowest weed control efficiency was recorded in weedy check plots. This result is similar to the report of Adewale et al. (2019) who work on management practices of Sesame production in Kano and revealed that the weedy check consistently produced significantly lowest weed control efficiency than all other treatments in all the locations of the experiment.

Pendimethalin at 1.0 kg a.i. ha^{-1} and application of 2.0 kg a.i. ha^{-1} of butachlor produced similar highest fresh bulb yield, while hoe weeding at 3 WAT and butachlor at 2.0 kg a.i. ha^{-1} recorded the highest unmarketable yield. This may be due to the reason that application of initial pre-emergence application of pendimethalin and butachlor controlled the germination of the weed seeds satisfactorily which resulted in better yield of the crop. The results is in agreement with the report of Chattopadhyay *et al.* (2016) who revealed that sole application of pendimethalin recorded the maximum bulb yield, bulb weight and marketable bulb yield. The interaction of the two factors also revealed that plant population of 333,333 plants/ha in combination with butachlor at the rate of 2.0 kg a.i. ha^{-1} gave the lowest weed density with highest weed control efficiency. The highest unmarketable bulb yield was recorded under plant population of 250,000 plants/ha with the use of hoe weeding at 3 WAT.

CONCLUSION

From the present investigation, weed density and weed control efficiency was better supported with plant population of 333,333 plants/ha. All the weed control treatments significantly contributed to the control of weeds in onion. However, the use of pre emergence application of pendimethalin and butachlor at the rate of 1.0 and 2.0 kg a.i. ha^{-1} supplemented by one hoe weeding respectively were the most effective in growth and yield parameters, but all rates of the pre emergence herbicide effectively reduced weed density and with high weed control efficiency. Pre-emergence application of pendimethalin and butachlor at the rate of 1.0 and 2.0 kg a.i. ha^{-1} can suppress weeds for a longer period of time and enhance the productivity of onion. It is therefore recommended that pre-emergence application of pendimethalin at the rate of 1.0 kg ai. ha^{-1} or butachlor at the rate of 2.0 kg a.i. ha^{-1} with one hoe weeding respectively can suitably control weeds in onion field.

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