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Effects of Defoliation Stages and Defoliation Intensity on Growth and Yield of Garlic (Allium sativum L.) In Sokoto, Nigeria.

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Abstract: *Field trials were conducted during 2012/2013 and 2013/2014 dry seasons at the Teaching and Research Fadama Farm, Usmanu Danfodiyo University, Sokoto (latitude $13^0\ 0^1$ N; longitude $5^0\ 15^1$ E; altitude, 350m above sea level), to study the effect of defoliation stages and defoliation intensity on the growth and yield of garlic (Allium Sativum L.). Randomized complete block design was used with factorial combination of defoliation stages and defoliation intensity. The treatment combinations were replicated three times. Results obtained revealed that defoliation stages and defoliation intensity had significantly affected ($p<0.05$) growth and yield parameters such as plant height, leaf number, bulb weight, cloves weight per bulb, clove diameter and cured bulb yield in both seasons. It was concluded that garlic defoliated at seedling and reproductive stages produced similar and higher garlic in terms of growth and yield performance than that defoliated at vegetative stage. The yield appreciated to defoliation intensity between zero and 40% intensity but continues to depreciate between 40% and 80% intensity.*
Keywords: *Defoliation stages; Defoliation intensity; Garlic; Yield; Cloves.*

I. Introduction

Garlic (Allium sativum L.) belongs to the family Alliaceae (Hanelt, 1990). Garlic originated in central Asia and later spread to Mediterranean region (Simon, 2001, Kilgori et al., 2005). It is grown in both temperate and tropical climates (FAO, 2001). Garlic is one of the most promising vegetable crops cultivated during dry season under irrigation in the Northern part of Nigeria because of its commercial values (Miko, 2000a). However, it is a well known fact that during off-season, same quantity of garlic is sold for twice or thrice the value of its onion counterpart (Kilgori, 2004). Despite these benefits obtained from its production, there has been little research effort geared towards increase production as regards to appropriate agronomic practices such as use of optimum defoliation stages and defoliation intensity for growth and yield of garlic. Production of vegetables is one of the major occupations of people in Sokoto and neighbouring States in Northwestern Nigeria, more especially during dry season when rainy season cultivation is over (Ahmed, 2006). This virtually stems the tide of rural-urban migration and is both an income generation and source of employment to a large population of otherwise redundant labour force (Ahmed, 2006).

According to Wikipedia, (2012) Defoliation is the process of removal of leaves from a tree other than natural leaf fall. A defoliant is a chemical sprayed or dusted on plants to cause its leaves to fall off (Meyer 1998). Recently, studies in crop defoliation have been receiving more attention to determine the effect of removing leaves for livestock, industrial use and on the final yield for human consumption using various crops (Rahman et al., 2008). In Nigeria, Ogunlela and Ologunde (1985) compared varying defoliation intensity applied at different Defoliation Stages on sorghum. Yahya (2000) determined the effect of variety and defoliation on grain cowpea. Ibrahim (2001), worked on the effect of stages and intensity of defoliation on the growth and yield of grain cowpea. Silas (2008) also assessed on the effect of intensity of defoliation and spacing on cowpea. While Rahman et al. (2008) studied the effect of defoliation at different Defoliation Stages on yield and profitability of cowpea (Vigna unguiculata (L.) Walp.). Ibrahim et al. (2010) reported the effect of defoliation on the profitability of cowpea. Badi et al. (2012) worked on the response of vegetable cowpea (Vigna unguiculata) to intra-row spacing and defoliation. All these studies concluded that yield response depends on the extent of defoliation.

Therefore, this research was carried out with a view to determining both the most suitable growth stage to defoliate garlic and appropriate defoliation intensity for optimum yield of garlic in Nigeria.

II. Materials And Methods

Field trials were carried out during 2012/13 and 2013/14 dry seasons at Usmanu Danfodiyo University, Fadama Teaching and Research Farm, Sokoto (latitude 13°01'N; longitude 5°15'E, 300 m above sea level) to investigate the effects of defoliation stages and defoliation intensity of garlic. The site is a low lying Sokoto and Rima river flood plain (Fadama). The land is submerged by flood water from August/September to October/November. The area is characterized by a long dry season with cool air (November-February), hot dry air during hot season from March to May (Kowel and Knabe, 1978). The meteorological data for the period of the experiment are minimum temperature of about 25.0 and 28.0°C and maximum temperatures of 30.0 and 36.5°C. Relative humidity ranged from 27 to 35% in the mornings and 38 to 45% in the evenings. Soil of the experimental site was sandy loam with a pH of 5.70 (in H_2O), 7.7 to 8.8% organic carbon; 0.85 to 0.88% N and available phosphorus of 0.54 to 1.93 ppm.

The treatments consisted of three defoliation stages (seedling stage from clove emergence to 4 weeks after sowing (WAS), vegetative stage was between 4 WAS and 7 WAS, while reproductive stage ranges from 7 WAS to 10 WAS) and defoliation intensity which was determined using meter rule and scissors to trim the leaves based on height (0% or no defoliation, 40% leaves defoliation and 80% defoliation), arranged in all possible factorial combinations and laid out in a randomized complete block design with three replications. Individual plot size was 1.5x2 m with 2.08 m^2 as net plot size. The spacing used was 15x10 cm with a single clove per hill. To obtain uniform maturity, irrigation was stopped two weeks before harvesting. Fertilizers NPK (15: 15: 15) was applied at the rates of 80, 50 and 50 kg ha^{-1}, respectively. Nitrogen (45-46% N) was split applied at sowing and at 4 weeks after sowing. All of the P and K were applied at sowing. All the fertilizers were incorporated into the soil in order to minimize losses. Bulbs were harvested when the leaves had turned pale green and started falling. Data were collected on plant height, number of leaves per plant, bulb weight and cured bulb yield. Data were analyzed statistically and multiple comparisons of treatment means were carried out using Duncan's New Multiple Range Test (Little and Hills, 1978).

III. Results

The result indicated that defoliation stages had significantly affected ($p<0.05$) plant height and number of leaves per plant at 10 WAS during 2012/2013 season only. Defoliation at seedling stage produced significantly taller plants with more number of leaves per plant than the shorter plants with less number of leaves produced after defoliation at vegetative stage.

Defoliation intensity had significantly affected plant height and number of leaves per plant of garlic at 10 WAS during both seasons. In both seasons, zero percent defoliation intensity produced significantly taller plants with more number of leaves per plant than the shorter plants with less number of leaves produced by 80 percent defoliation intensity. The interaction of the factors was not significant.

Table 2 shows the result of bulb weight and cured bulb yield of garlic as affected by defoliation stages and defoliation intensity during 2012/2013 and 2013/2014 seasons. The result revealed that bulb weight was significantly affected only during 2013/2014 season, with defoliation at seedling stage and defoliation at reproductive stage being statistically at par and had significantly produced heavier bulbs than the ones produced after defoliation at vegetative stage.

Defoliation intensity had significantly affected bulb weight of garlic only in 2012/2013 season with zero percent defoliation intensity produced significantly higher bulb weight compared to the lower bulb weight produced by 40 and 80 percent defoliation intensity that were at par.

However, defoliation stages had significantly affected cured bulb yield of garlic during both seasons with garlic defoliated at seedling and reproductive stages produced significantly higher bulb yield after curing than garlic defoliated at vegetative stage that produced significantly the lowest bulb yield. Defoliation intensity had no significant effect ($p>0.05$) on cured bulb yield of garlic during both seasons.

Table 3 showed interaction between defoliation stages and defoliation intensity on cured bulb yield of garlic during 2013/2014 dry season. When defoliation stages were held constant and examined across defoliation intensity, defoliation at seedling stage with 0% defoliation intensity and defoliation at reproductive stage with 40% defoliation intensity produced significantly the highest cured bulb yield than defoliation at vegetative stage with 80% defoliation intensity that has the lowest cured bulb yield. All other interacted treatments were statistically similar.

IV. Discussion

Defoliation stages had significantly affected growth and yield characters such as plant height, number of leaves per plant, bulb weight per plant and cured bulb yield in 2012/2013 and 2013/2014 dry seasons. Defoliation at vegetative stage produced significantly shorter plants with fewer leaves per plant at maturity. This may be due to the removal of young expanding leaves that suppressed the vegetative growth and altered partitioning. This agreed with earlier findings of Selter et al. (1980) who reported that defoliation had reduced the rate of leaf photosynthesis and alters the ability of the photosynthetic source leaves to export assimilate and Ibrahim et al. (2010) also reported that upper leaves were more active for photosynthesis than basal ones and therefore altered partitioning. While, according to Ogunlela and Ologunde (1985) if defoliation occurs in sorghum too early in the growth cycle, it is likely to depress the grain yield. Also Asgar and Ingram (1993) had shown that when the flag leaves of wheat were removed at different defoliation stages it significantly reduced grain yield of wheat. This indicates involvement of an effective compensatory mechanism which helps in production of more assimilates in the remaining leaves.

Defoliation intensity had significantly affected growth and yield characters such as plant height, number of leaves per plant, bulb weight per plant and cured bulb yield in 2012/2013 and 2013/2014 dry seasons. Defoliation intensity of 80% produced significantly shorter plants with fewer leaves at maturity. This may be due to the intensity of leaves removal which is in conformity with Muro et al. (2001) who reported that the effect of defoliation intensity depends on the foliar surface area eliminated and on the growth at which it takes placed. Moreover, Rahman et al. (2008) and Badi et al. (2012) all worked on cowpea and reported that reduction in yield with increasing defoliation intensity could be due to lesser leaf area unable to supply available assimilates to the sink.

The yield loss could be because there was an increase in the defoliation intensity as found by Muro et al. (2001) studies of sunflower showed that crop yield loss increased with increasing level of defoliation. Rahman et al., (2008) also reported that Regression functions for the relationship between yield loss and defoliation level at the three growth stages of cowpea were positive and that there was an increase in yield loss as the intensity of defoliation increased but this influence was only significant in the vegetative stage.

Defoliation at reproductive stage and 40% defoliation intensity was found to produce the highest yield combination for optimum cured bulb yield. This could be attributed to the positive effect of frequent irrigation and availability of adequate food reserve material for the developing organs, which all helped progressively in the increased growth and development potentials of the crop. Adequate moisture has no doubt made the available soil nutrients to be more often utilized by the crop effectively.

V. Conclusion

It was concluded that defoliation at different growth stages and different intensities had affected the growth and yield performance of garlic. Garlic defoliated at seedling and reproductive stages produced similar and higher garlic in terms of growth and yield performance than vegetative stage with the lowest performance while the yield has appreciated to defoliation intensity between zero and 40% but continue to depreciate between 40% and 80% intensity.

Table 1. Plant height and number of leaves per plant of garlic as affected by defoliation stages and defoliation intensity at 10 WAS during 2012/2013 and 2013/2014 seasons at UDU, Teaching and Research Fadama Farm, Sokoto.

	Plant height (cm)		**Number of leaves per plant**	
Treatments	2012/2013	2013/2014	2012/2013	2013/2014
Defoliation stages				
Seedling	35.39a	39.89	9.56a	9.46
Vegetative	26.22b	37.61	6.83c	10.04
Reproductive	33.20a	42.46	8.00b	10.04
SE ±	1.212	0.963	0.352	0.350
Significance	**	NS	**	NS
Defoliation intensity (%)				
0	36.47a	41.47a	9.36a	10.83a
40	34.11ab	40.39a	8.38b	9.52b
80	32.04b	35.03b	7.36c	8.93b
SE ±	1.401	0.834	0.305	0.303
Significance	*	*	**	*
Interaction				
DS x DI	NS	NS	NS	NS

Within a treatment group, means in a column followed by same letter(s) are not significantly different at 5% level using Duncan New Multiple Range Test (DNMRT). NS = Not significant, * = Significant at 5% and ** = Significant at 1% levels probability. WAS = Weeks after sowing, DS = Defoliation Stages and DI = Defoliation intensity.

Table 2. Bulb weight and cured bulb yield of garlic as affected by defoliation stages and defoliation intensity during 2012/2013 and 2013/2014 seasons at UDU, Teaching and Research Fadama Farm, Sokoto.

	Bulb weight per plant (g)		**Cured bulb yield (kgha^{-1})**	
Treatments	2012/2013	2013/2014	2012/2013	2013/2014
Defoliation stages				
Seedling	1.01	5.97a	191.94ab	708.50a
Vegetative	1.10	4.33b	170.07b	464.40b
Reproductive	1.04	5.42a	195.59a	642.10a
SE ±	0.091	0.251	7.267	46.548
Significance	NS	**	*	**
Defoliation intensity (%)				

0	1.34[a]	5.24	189.26	629.40
40	1.04[b]	5.22	185.94	608.70
80	1.00[b]	5.19	178.58	543.10
SE ±	0.079	0.218	6.294	30.312
Significance	*	NS	NS	NS
Interaction				
DS x DI	NS	NS	NS	*

Within a treatment group, means in a column followed by same letter(s) are not significantly different at 5% level using Duncan New Multiple Range Test (DNMRT). NS = Not significant, * = Significant at 5% and ** = Significant at 1% levels probability. DS = Defoliation Stages and DI = Defoliation intensity.

Table 3. Cured bulb yield ($kgha^{-1}$) of garlic as affected by defoliation stages and defoliation intensity interaction during 2013/2014 dry season at UDU, Teaching and Research Fadama Farm, Sokoto.

	Defoliation intensity (%)		
Defoliation stages	0	40	80
Seedling	808.08[a]	657.67[ab]	659.67[ab]
Vegetative	603.58[ab]	511.83[ab]	227.92[bc]
Reproductive	554.33[ab]	803.08[a]	568.92[ab]
SE ±	80.624		

Means followed by the same letter(s) within a set of interaction are not significantly different at 5% level of probability using Duncan New Multiple Range Test (DNMRT).

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