Response of False horn plantain to different plant densities and frequency of handweeding

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SUMMARY

The study, which was carried out at the Crops Research Institute, Kumasi, Ghana, from April 1992 to March 1995, aimed at determining (i) the optimum plant density of False horn plantain for maximum yield, and (ii) the optimum frequency of handweeding for economic returns. Results indicated that the optimum plant density for False horn was 1667 plants per hectare. At this density, the significantly highest bunch weight was 8.0 kg per plant. In Ghana, plantain is mostly sold as bunches and, therefore, bunch weight per plant rather than yield per hectare is of paramount importance. Handweeding, as weed control measure, proved to result in high economic returns. Keeping the field weedfree for the first 4 weeks followed by slashing every 12 weeks (4-IWP × 12-FUS) produced the highest economic returns of 71.5 per cent over the farmer's practice of weeding at only 12-week intervals from planting.

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RÉSUMÉ

BANFUL, B., BOLFREY-ARKU, G. E. K., ADU-TUTU, K. & ASANTE, J. S.: *La réaction de plantain de Fausse Corne aux différentés densités de plante et la fréquence de désherbage à la main.* L'étude s'est déroulée à l'Institut de Recherche des Cultures à Kumasi au Ghana d'avril 1992 au mars 1995 avec les buts de déterminer (i) la densité optimum de plante de la plantain de Fausse Corne (False Horn) pour le rendement maximum, et (ii) la fréquence optimum du désherbage à la main pour les rendements rentables. Les résultats indiquaient que la densite optimum de plante pour Fausse Corne était 1667 plantes par hectare. A cette densité, le poids de régime le plus considérablement élevé de 8.0 kg par plante était obtenu. Au Ghana, le plantain est vendu le plus souvent en régime, ainsi, le poids de régime par plante plutôt que le rendement par hectare est d'une suprême importance. Le désherbage à la main comme un moyen de contrôle de mauvaise herbe, faisait preuve de donner un rendement considérablement rentable. Gardant le champ dépourvu de mauvaise herbe pour les premières 4 semaines suivi par l'entaillage chaque 12 semaines (4-IWP × 12-FUS) produisait les rendements rentables les plus élevés de 71.5 pour cent au-dessus des rendements produits sous la pratique de cultivateurs de désherber seulement à intervalles de 12 semaines après la plantation.

Introduction

Maximizing the yield potential of plantain depends primarily on the appropriate planting density. The optimum density, however, varies for each cultivar and management level (Gowen, 1995). Optimum plant densities have been determined for False horn plantain in several countries such as Colombia (1600 plants/ha), Puerto Rico (4300 plants/ha), and Nigeria (3200 plants/ha) (Irizarry *et al.*, 1978; Obiefuna, Majumder & Ucheagwu, 1982). In Ghana, plantains are generally planted haphazardly by local peasant farmers, resulting in widely spaced plants and low yields. In addition, the random planting promotes weeds on the farm.

The effect of weed growth on the plantain is reflected in reduced leaf numbers, reduced leaf longevity, retarded growth, delayed maturity, poorly filled fingers, and loss of bunch yield (Ndubizu, 1991; Obiefuna, 1991). Weeds also

predispose plantain to attack by plant parasitic nematodes, since they may serve as alternate hosts (Anwar, Rauf & Goris, 1992). In plantain cultivation, the most critical factor in weed control is the frequency of control. However, farmers tend to slash only when weeds start to tower over the crop, about 2 to 4 months after planting, and thereafter brushing up at 12-week intervals (Hemeng *et al.*, 1995). This practice invariably results in yield decline as reported by Ndubizu (1985) that handweeding at intervals ranging from 2 to 10 weeks led to yield decline from 16.6 to 2.3 t/ha).

The study, therefore, aimed at determining the optimum plant density required to maximize bunch weight per plant of False horn plantain, and the optimum frequency of handweeding for economic returns.

Materials and methods

Site

The study was carried out at the Crops Research Institute, Fumesua, Ghana from April 1992 to March 1995. The rainfall pattern of the area is bimodal from March to July and from September to November. The dry period is from December to February. The mean annual rainfall is 2000 mm and the mean monthly temperature is 30.7 °C. The soils of the site are ferric acrisols with a *p*H of 5.0. The site was previously cropped to cassava for 3 years. The vegetation was initially slashed but not burnt. Two experiments were carried out.

Experiment 1 - Influence of different plant densities on yield of False horn plantain

Experiment 1 aimed at determining the optimum plant density required to maximize bunch yield of False horn plantain. The experiment was carried out from April 1992 to October 1993. There were six plant densities: 3333 plants/ha (2 m × 1.5 m), 2500 plants/ha (2 m × 2 m), 1667 plants/ha (3 m × 2 m), 1600 plants/ha (2.5 m × 2.5 m), 1333 plants/ha (3 m × 2.5 m), and 1111 plants/ha (3 m × 3 m). The design was a randomized complete block with three replications. Each plot had planting holes measuring 30 cm × 30 cm. At planting, Carbofuran 3 per cent (Furadan 3G) granules were applied at a rate of 2g per planting hole to control nematodes and banana weevils (*Cosmopolites sordidus*). Weeds were controlled initially by applying Glyphosate (Roundup) at 4l/ha. Plantain was planted 2 weeks later on all plots. Subsequent weed control consisted of a combination of three manual weedings with a cutlass and two Glyphosate applications at the same rate as before. Nitrogen (170 kg N/ha), phosphorus (41.7 kg P/ha), and potassium (192 kg K/ha) (Ministry of Agriculture, Fisheries and Forestry, 1988) in the form of sulphate of ammonia, triple super phosphate, and muriate of potash, respectively, were applied in four doses at 1, 4, 6 and 12 months after planting (MAP). The fertilizers were applied in a ring of 50 cm radius around each plantain plant.

Growth and yield data were taken on 10 plants in the two central rows for each plot. Growth data collected comprised plant height, pseudostem girth (1 m above soil surface), cumulative number of functional leaves, and number of days to flowering. Yield and yield components data were bunch weight per plant, yield (bunch weight × number of plants per hectare), number of hands/bunch, number of fingers/bunch, and finger weight/bunch.

Experiment 2 - Effect of frequency of handweeding on yield of plantain for economic returns

Experiment 2, a follow-up to Experiment 1, aimed at determining the optimum frequency of handweeding and its effect on the growth and yied of False horn plantain planted at a density of 1667 plants/ha (3 m × 2 m). It was undertaken from November 1993 to March 1995. The design was a randomized complete block with four replications. The treatments were factorial combinations of initial weedfree periods of weeks after planting (IWP) and follow-up slashing (FUS) of weekly intervals (Table 1). The initial weedfree on all plots was carried out by manual weeding with a cutlass.

TABLE 1

Combinations of Initial Weed-free Periods and Follow-up Slashing

0 IWP	*4 IWP*	*8 IWP*	*12 IWP*
4 FUS	4 FUS	4 FUS	4 FUS
8 FUS	8 FUS	8 FUS	8 FUS
12 FUS	12 FUS	12 FUS	12 FUS

The procedures for planting of the False horn plantain, data collection and other management practices, except weed control, were the same as in Experiment 1. In addition, a partial budget analysis (based on yield/ha) was done.

Assumptions made in the analysis were as follows:

1. Fifteen man-days were required for weeding one hectare of plantain farm at a time.
2. The cost of weeding was ¢1,000.00 per man-day.
3. Allowance for 10 per cent losses due to diseases and pests.
4. A bunch of plantain sold at ¢300.00 per kg.

Results

Effect of plant density on growth and yield of plantain

At flowering, there was no significant difference in height of plantain for the various densities (Table 2). However, the differences among the densities in number of functional leaves and number of days to flowering were significant. Plants planted at a density of 1667 plants/ha significantly flowered earlier and had more functional leaves than plants of the other densities (Table 2). Bunch weight per plant was 65 per cent significantly ($P<0.05$) greater in plants at a density of 1667 plants/ha than the average bunch weight of the other densities. Similarly, finger weight of plantain was significantly greater at a density of 1667 plants/ha. However, for yield per hectare, plants at a density of 3333 produced significantly higher yield than the other densities (Table 3). The number of fingers/bunch and number of hands/bunch did not, however, differ significantly between the various plant densities.

TABLE 2

Effect of Different Plant Densities on Plant Height, Number of Functional Leaves at Flowering, and Number of Days to Flowering of False Horn Plantain

Density (plants/ha)	*Plant height (cm)*	*Number of functional leaves at flowering*	*Number of days to flowering*
3333	240.5	6.0	426
2500	243.0	7.9	410
1667	248.5	10.0	390
1600	236.7	7.5	464
1333	240.9	7.2	452
1111	230.2	6.7	488
Mean	240.0	7.6	438.3
CV (%)	6.9	7.1	9.9
LSD ($P<0.05$)	NS	1.1	15.0

Effect of frequency of handweeding on growth and yield of plantain

The predominant weeds were *Chromolaena odorata, Centrosema pubescens, Cyperus* spp., *Syndrella nodiflora,* and *Aspelia africana.* The number of functional leaves at flowering was highest when plots were kept weedfree for the first 4 weeks after planting (WAP). This was 32 per cent significantly ($P<0.001$) higher than that of the control but similar to those of the other treatments (Table 4). Follow-up slashing (FUS) at 4-week intervals had 20 per cent more ($P<0.01$) leaves at flowering than the no follow-up slashing treatment. The period of initial weedfree did not significantly affect plant height. However, follow-up slashing at 4-week intervals produced the tallest plants of 168.4 cm, while slashing at 12-week intervals produced the shortest plants, the difference (31 per cent) being significant ($P<0.05$) (Table 5). There was also a significant IWP × FUS interaction for number of suckers produced

TABLE 3

Different Plant Densities and Their Effect on Yield and Components of Yield of False Horn Plantain

Density (plants/ha)	*Bunch weight (kg/plant)*	*Yield (t/ha)*	*Number of hands/bunch*	*Number of fingers/bunch*	*Finger weight (g)*
3333	5.3	17.7	6	26	230.2
2500	5.6	14.0	6	26	240.4
1667	8.0	13.3	7	28	208.2
1600	4.7	7.8	6	26	220.8
1333	4.4	7.3	6	25	212.4
1111	4.2	7.0	6	25	207.6
Mean	5.4	11.3	6.2	26	231.9
CV (%)	17.2	15.2	7.2	9.9	14.1
LSD (P<0.05)	2.3	3.0	1.1	4.0	30.4

TABLE 4

Number of Functional Leaves at Flowering (13 MAP) of Plantain as Influenced by Initial Weed-free Period (IWP) and Follow-up Splashing (FUS)

IWP (wks)	*Number of functional leaves*	*Mean*	*LSD*	*CV (%)*
0	7.4			
4	9.8	8.9	1.1***	6.8
8	8.8			
12	9.6			
FUS				
None	7.8			
4-weekly	10.0	8.9	1.1**	6.7
8-weekly	9.0			
12-weekly	8.8			

*** = P<0.001 ** = P<0.01

TABLE 5

Effect of Follow-up Slashing (FUS) on Plant Height and Pseudostem Girth at Flowering (13 MAP) of False Horn Plantain

FUS	*Plant height (cm)*	*Girth (cm)*
None	138.3	29.5
4-weekly	168.4	39.9
8-weekly	132.6	32.1
12-weekly	128.5	29.8
Mean	142.0	32.8
CV (%)	10.2	12.5
LSD (P<0.05)	31.5	7.5

(Table 6). A 4-week IWP followed by 4-weekly FUS produced the highest number of suckers. Additionally, there was a significant IWP × FUS interaction for yield per hectare (Table 7). A 4-week IWP followed by either 4-, 8-, or 12-weekly FUS produced significantly higher yield than a 4-week IWP without any FUS.

Partial budget analysis of handweeding strategies

Table 8 shows the partial budget analysis based on yield per hectare. Considering that weeding frequency was the only variable, the option that had the highest returns of 71 per cent compared with the farmer's practice was a combination of a 4-week IWP and a 12-weekly FUS.

Discussion

The study showed that for good bunch weight per plant of False horn plantain, the required plant spacing was 3 m × 2 m (1667 plants/ha). The study emphasized bunch weight per plant because in Ghana, plantain was sold as bunches and not as individual fruits. As such, fruit size rather than fruit mass was of paramount importance. The

TABLE 6

Effect of Initial Weed-free Period (IWP) and Follow-up Slashing (FUS) on Mean Number of Suckers at Flowering (13 MAP)

IWP (wks)	Number of suckers per plant				
	FUS				
	None	4-weekly	8-weekly	12-weekly	Mean
0	0.1	0.1	0.1	0.1	0.10
4	0.8	3.2	1.7	1.0	1.68
8	0.3	2.0	1.0	1.6	1.23
12	0.0	2.3	1.2	1.2	1.18
Mean	0.30	1.90	1.00	0.98	
CV (%)	8.5	6.5	2.3	11.5	
LSD	IWP = 0.5***		FUS = 0.5***	IWP × FUS = 1.1*	

*** = $P<0.001$ * = $P<0.05$

TABLE 7

Effect of Initial Weed-free Period (IWP) and Follow-up Slashing (FUS) on Mean Yield (t/ha)

IWP (wks)	Yield (t/ha)				
	FUS				
	None	4-weekly	8-weekly	12-weekly	Mean
0	0.5	0.8	0.8	0.8	0.70
4	2.5	11.8	10.5	8.8	8.40
8	1.5	10.0	8.7	6.8	6.80
12	2.3	7.0	5.8	4.7	5.00
Mean	1.7	7.1	6.5	5.3	
CV (%)	5.6	8.1	12.3	10.8	
LSD	IWP = 1.5***		FUS = 1.5***	IWP × FUS = 2.8*	

*** = $P<0.001$ * = $P<0.05$

higher bunch weight at a density of 1667 plants/ha could be partially attributed to a higher, active leaf area as reflected in the number of leaves at flowering which led to higher total dry matter production. Additionally, it could be due to the heavy weight of fruits forming the bunch. These assertions were in accord with the report by Banful *et al.* (1999) that number of functional leaves at flowering and fruit weight/bunch were significantly and positively correlated with bunch weight.

Planting at high density resulted in the formation of small bunches with smaller fruit size (Gowen, 1995). A similar observation had been made in the study where at a density above 2500 plants/ha, the plantain had 46 per cent less bunch weight/plant and 18 per cent less finger weight/bunch than similar yield components at density 1667 plants/ha. Severe competition for resources such as light, water, and nutrients could largely explain such an observation. The configuration of the planting was also important as reported by Gowen (1995) that a configuration based on rectangle or hexagon with single plants was able to minimize the use of available radiation and, therefore, produced higher yields per unit area. Thus, the high bunch weight per plant at 1667 plants/ha could be partly due to the rectangular configuration of the planting.

Similar observations had been reported in South Africa (Robinson, Nel & Bower, 1989). At the plant densities less than 1667 plants/ha, the poor performance of the plants could be due to the intense weed competition caused by wide spaces between the plants which enchanced sunlight penetration and increased weed growth (Robinson, 1995). This is because plant canopy closure was slower at the lower than at the higher densities. Therefore, although weeds were controlled at specific periods in the experiment, competition from weeds was possible in the lower plant density plots.

This study had also shown that keeping the plantain field weedfree for the first 4 weeks

TABLE 8

Partial Budget Analysis of Different Handweeding Strategies for Weed Control of Plantain

Strategies	*Mean yield (kg/ha)*	*Gross benefit (cedis)*	*Adjusted gross benefit (cedis)*	*Total variable cost (cedis)*	*Net benefit (cedis)*	*Marginal rate of return (%)*
4-IWP × 0 FUS	2550.5	765.150	688,635	15,000	673,635	11.3
4-IWP × 4 - FUS	11885.7	3,565,710	3,209,139	195,000	3,014,139	21.0
4-IWP × 8 - FUS	10502.1	3,150,630	2,835,567	105,000	2,730,567	57.0
4-IWP × 12 - FUS	8835.1	2,650,530	2,385,477	90,000	2,310,477	71.5
8-IWP × 4 - FUS	10002.0	3,000,600	2,700,540	210,000	2,580,540	16.1
8-IWP × 8 - FUS	8668.4	2,600,520	2,340,468	120,000	2,220,468	37.0
8-IWP × 12 - FUS	6884.7	2,065,410	1,858,869	90,000	1,798,869	36.3
12-IWP × 0 - FUS	2333.8	700,140	630,126	45,000	585,126	28.0
12-IWP × 4 - FUS	7001.4	2,100,420	1,890,378	195,000	1,785,378	12.0
12-IWP × 8 - FUS	5884.5	1,765,350	1,588,815	120,000	1,513,815	22.5
12-IWP × 12 - FUS	4667.6	1,400,280	1,260,252	105,000	1,155,252	25.7
0-IWP × 12 - FUS (Farmer's practise)	833.5	250,050	225,045	60,000	165,045	-

followed by slashing every 12 weeks resulted in high economic returns of 71.5 per cent over the farmer's practice of weeding at only 12-week intervals from planting. However, Staver (1991) had a dissenting view which indicated that frequent weed control, preferably every 4 weeks, was essential to minimize yield reduction in plantain. But Staver (1991) failed to comment on the economic implications of his results. In this study, labour cost as an important factor in assessing the economic feasibility of the handweeding strategy to be adopted was considered, since handweeding was labour-based. After the initial 4-week weedfree period, weeding every 12 weeks resulted in 62.5 per cent less labour cost than weeding every 4 weeks.

Akobundu (1987) also indicated that for the first 12 weeks of its growth, a sucker depended on the food reserves in its corm and , therefore, it was least susceptible to competition from weeds. Further, Ndubizu (1991) indicated that the critical period of weed competition in plantain was from flowering to fruit bulking. The implication was that frequent weeding before flowering of plantain might not be of much significance and, therefore, not cost effective. Handweeding took about 50 per cent of farmers' time (Gowen, 1995), leaving less time for other on-farm and off-farm activities. Thus, adopting the recommendation of this study could improve the efficiency of time used for on-farm and off-farm activites.

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