

Influence of Weeds on Seed Development, Yield Components and Seed Quality in Okra (*Abelmoschus esculentus*)

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ABSTRAK

Kehadiran rumput diketahui mempengaruhi hasil, tetapi kesannya ke atas perkembangan dan mutu biji benih tidak banyak dilaporkan. Oleh itu kajian ini dijalankan dengan objektif untuk menentukan kesan rumput ke atas pengumpulan berat kering biji benih, komponen hasil dan kualiti biji benih bendi (*Abelmoschus esculentus*). Tanaman bendi ditanam di kawasan yang rumput dikawal secara manual, menggunakan racun herba (*Gramoxone*) atau rumput tidak dikawal. Buah-buah bendi yang terbentuk dipetik pada hari ke 15, 20, 25, 30, 35 atau 40 hari selepas berbunga (DAF). Pengumpulan berat kering biji benih, berat 1000 biji benih, percambahan dan kemunculan anak benih di ladang diuji ke atas biji benih yang dipetik. Komponen hasil (buah pokok¹ dan biji benih buah¹) dinilai pada 40 DAF. Rumput didapati tidak mempengaruhi jangkamasa untuk biji benih mencapai tahap maksima pengumpulan berat kering tetapi mengurangkan berat 1000 biji benih, buah pokok¹ dan biji benih buah¹. Biji benih yang dipetik dari petak dimana rumput dikawal secara manual menghasilkan peratus percambahan dan kemunculan anak benih yang tertinggi jika dibandingkan dengan biji benih yang dipetik dari petak yang dikawal dengan racun herba atau tidak dikawal. Rumput ($\geq 17.5\%$) didapati tidak mempengaruhi jangkamasa biji benih mencapai tahap maxima kebernasan dan kualiti biji benih secara terus, tetapi mengurangkan kadar pengumpulan berat kering biji benih dan ini seterusnya merendahkan peratus percambahan dan kemunculan anakbenih di ladang.

ABSTRACT

The presence of weeds during crop production is known to affect yield. However, changes to yield components, seed development and seed quality are not well documented. The study was conducted to determine the effect of weeds on accumulation of seed dry weight, yield components, and seed quality in okra (*Abelmoschus esculentus*). Treatments in the field consisted of manual weeding, no weeding or herbicide spraying. Flowers were tagged daily at flowering stage and fruits were harvested at 15, 20, 25, 30, 35 or 40 days after flowering (DAF). Changes in accumulation of seed dry weight, 1000-seed weight, seed germination and field emergence were evaluated following all harvests. Yield components (fruits plant⁻¹ and seeds fruit⁻¹) were evaluated at 40 DAF. The presence of weeds did not affect the duration for seeds to reach maximum dry weight, but reduced 1000-seed weight, fruits plant⁻¹ and seeds fruit⁻¹. Seeds harvested from manually weeded plots resulted in higher germination and field emergence compared with those from herbicide or no weeding plots. The presence of weeds ($\geq 17.5\%$ coverage) did not affect the time taken to achieve maximum germination and seed quality directly; however, weeds directly affected rate of accumulation of seed dry weight and seed size which subsequently affected germination and field emergence.

INTRODUCTION

Weeds compete for space, light, water and nutrients, and thus their presence can adversely affect crop growth and yields. The reduction in yields due to weed competition during production has been reported in dwarf

beans (Roberts, 1976), groundnut and cotton (Drennan and Jennings, 1977) and okra (Iremiren, 1988). The presence of weeds has also been reported to affect yield component (1000-seed weight) in mung beans (Yadav *et al.*, 1983).

The effect of weeds on seed development and quality during seed production is little or not known in many crops although the presence of weeds is known to affect growth, yield component and yield in general. Therefore, this study was conducted to determine the effect of weeds on seed development, germination and field emergence of harvested seeds in okra (*Abelmoschus esculentus*).

MATERIALS AND METHOD

One okra cultivar, Mk Be 1, was used in this study. Recommended agronomic practices were followed during production following sowing in the field. Prior to planting, the seeds were treated with fungicide (thiram).

Treatments were as follow: 1) manual weeding, 2) using herbicide (Gramoxone) at 0.5 kg a.i. ha⁻¹ where plots were sprayed at 14, 35, 56, 77 and 98 days after planting (DAP), and 3) no weeding, where weeds were allowed to grow freely following sowing. Plot size for each treatment was 9 x 20 m. The treatments were arranged in a randomised complete block with four replications. Weed species were identified and percent weed cover from 1 m² area in each treatment plot was evaluated every 14 days after planting. Weeds in manually weeded plots were regularly controlled by hoeing or by hand.

Three to four flowers plant⁻¹ were tagged during anthesis (flowering) daily in the morning. Developing pods were hand-harvested at 15, 20, 25, 30, 35 or 40 days after flowering (DAF). Accumulated seed dry weight was determined immediately after harvest. The remaining seeds were dried at room temperature (25°C) to 9-12% seed moisture. Weight of 1000 seeds was taken and standard germination test (SG) (ISTA, 1976) using sand media at room temperature (25°C) were conducted on dried seeds for all harvests.

Ten plants were randomly selected from each plot to determine the number of fruits plant⁻¹ at final harvest (40 DAF). The fruits were than pooled and ten fruits were randomly selected to determine the number of seeds fruit⁻¹.

The seedling emergence test was conducted in the field for seeds harvested at 20, 25, 30, 35 and 40 DAF. The experimental design for the seedling emergence study was a completely randomised block with four replications per treatment. The percentage seedling emergence was recorded 21 days after planting.

Data for percent weed coverage, fruits plant⁻¹, seeds fruit⁻¹, weight of 1000 seeds, percent germination (laboratory) and percent seedling emergence (field) were analyzed by analysis of variance. Duncan Multiple Range Test (DMRT) at the 0.05 level of probability was used for separation of mean differences.

RESULTS

Weed Species and Coverage

Eleusine indica, *Echinochloa colona*, *Paspalum conjugatum*, *Cyperus rotundus* and *C. iria* were the dominant weeds growing during the first six weeks following sowing especially in no weeding plots. Broad-leafed weeds such as *Borreria latifolia*, *Euphorbia hirta*, *Ipomoea triloba* and *Mimosa invisa* dominated towards the end of the growing period.

The percent weed cover for herbicide control plots was 17.5% at 14 days after planting and it increased to 36.3% at 98 DAP (Table 1). Weed cover in manually weeded plots did not exceed 10% during the experimental period. Percent weed cover for no weeding plots was 20% at 14 DAP, but increased to ≥90% when okra plants started to flower at approximately 56 DAP. Plants started to flower at about the same time (56 DAP) in plots where weeds were controlled.

TABLE 1

Percentage weed cover following herbicide or no weeding treatments at different days after planting

Days after planting	Herbicide†	No weeding‡
14	17.5 a	20.0 a
28	21.3 ab	61.2 b
42	27.5 b	87.5 c
56§	29.3 b	95.0 d
70	35.5 b	95.0 d
84	36.3 b	96.0 d
98T	36.3 b	98.0 d

Means followed by the same letter are not significantly different as determined by Duncan Multiple Range Test (P=0.05).

† Weeds were sprayed with Gramoxone at 14 DAP and every 21 days thereafter.

‡ Weeds were allowed to grow freely.

§ Approximate date of first flowering.

Yield Components

The presence of weeds significantly reduced fruits plant⁻¹ and seeds fruit⁻¹ compared with manually weeded treatment (Table 2). Controlling weeds by manual weeding gave the highest number of fruits plant⁻¹ and seeds fruit⁻¹. For herbicide treatment (17.5-36.3% weed cover), the number of fruits plant⁻¹ was reduced by approximately 36% and the number of seeds fruit⁻¹ by 23%. However, when weeds were allowed to grow freely (no weeding, 20-95% weed cover), the number of fruits plant⁻¹ and seeds fruit⁻¹ were reduced by 70% and 37% respectively, compared with manually weeded treatment.

Seed Development and Quality

The percentage of seed dry weight (based on maximum seed weight) increased from 40% initially to 100% at 35 DAF regardless of the weed control treatments (Fig. 1). This indicates that maximum accumulation of seed dry weight in okra occurred at 35 DAF and was not affected by the presence of weeds.

TABLE 2
Effect of different methods of weed control on number of fruits plant⁻¹ and seeds fruit⁻¹

Treatment	Fruits plant ⁻¹	Seeds fruit ⁻¹
Manual weeding	30 a	125 a
Herbicide†	19 b	96 b
No weeding‡	9 c	81 c

Means followed by the same letter are not significantly different as determined by Duncan Multiple Range Test (P=0.05).

† Weeds were sprayed with Gramoxone at 14 DAP and every 21 days thereafter.

‡ Weeds were allowed to grow freely.

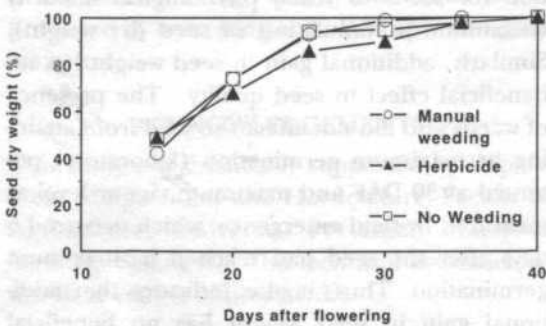


Fig. 1: Changes in accumulation of seed dry weight for okra seeds harvested at different seed growth stages

Plots weeded manually during seed production gave significantly higher 1000-seed weight over control treatment with herbicide or no weeding (Table 3). The weight of 1000 seeds increased from 31 g at 15 DAF to 76 g at 40 DAF for manual weeding treatment. The increase in 1000-seed weight for both herbicide and no weeding treatments was on the average of 26 g initially to 67 g at the final harvest date. The rate of accumulation of seed dry weight was 2.5, 2.4 and 2.3 g day⁻¹ for manual weeding, treatment with herbicide and no weeding, respectively, from 15 to 30 DAF. No accumulation of seed dry weight occurred between 30 to 35 DAF for all the three treatments. The rate of accumulation of seed dry weight increased at lower rates from 35 to 40 DAF, being 1.6, 1.4 and 1.2 g day⁻¹ for manual weeding, treatment with herbicide and no weeding, respectively.

The presence of weeds during seed production resulted in a lower percentage seed germination (Table 4). Harvesting seeds at 15 DAF gave lower germination (≤25%) than harvesting later for all the treatments. Although the percentage germination was lower in both herbicide and no weeding treatments over manual weeding, harvesting seeds at 35 DAF gave maximum percentage germination (SG) for all the treatments. However, germination declined when seeds were harvested 5 d later.

TABLE 3
Effect of different methods of weed control on seed weight (g 1000 seed⁻¹) harvested at different seed growth stages

Treatment	Days after flowering					
	15	20	25	30	35	40
Manual weeding	31a	43a	56a	69a	68a	76a
Herbicide†	27a	38b	51b	63b	61b	68b
No weeding‡	25a	38b	48b	59b	60b	66b

Means followed by the same letter are not significantly different as determined by Duncan's Multiple Range Test (P=0.05).

† Weeds were controlled with Gramoxone at 14 DAP and every 21 days thereafter.

‡ Weeds were allowed to grow freely.

TABLE 4
Effect of different methods of weed control on percentage germination for okra seeds harvested at different seed growth stages

Treatment	Days after flowering					
	15	20	25	30	35	40
Manual weeding	25a	35a	86a	99a	99a	86a
Herbicide†	17b	30b	79b	89b	89b	82b
No weeding‡	14b	19c	53c	84c	84c	67c

Means followed by the same letter are not significantly different as determined by Duncan's Multiple Range Test ($P=0.05$).

† Weeds were sprayed with Gramoxone at 14 DAP and every 21 days thereafter.

‡ Weeds were allowed to grow freely.

The percentage field emergence of the seedlings was significantly lower for no weeding treatment for all harvest dates compared with herbicide or manual weeding (Table 5). Maximum field emergence (67, 64 and 45% for manual weeding, herbicide and no weeding, respectively) was observed when seeds were harvested at 35 DAF.

DISCUSSION

The presence of weeds during growth period had little effect on the time of flowering in okra. However, >10% weed coverage prior to flowering affected number of fruits plant⁻¹ and seeds fruit⁻¹. A weed coverage of $\geq 17.5\%$ reduced the number of fruits plant⁻¹ in the range of 37-70%, whilst the number of seeds fruit⁻¹ was reduced by 24-35%. This indicates that number of fruits plant⁻¹ is a more sensitive yield component than number of seeds fruit⁻¹. Therefore, controlling weed coverage during production to $\leq 10\%$ is important to achieve a maximum potential number of fruits plant⁻¹ and seeds fruit⁻¹. The data was consistent with a report by Iremeren (1988) that a weed-free period prior to flowering gave highest number of fruits plant⁻¹ and fruit weight in okra. Amartalingam *et al.* (1980) also reported that a weed free period for the first 7 weeks after planting gave maximum kernel yield in groundnut.

Seed size was also affected when weeds were present during production, reflected by a reduction of 1000-seed weight when percent weed

TABLE 5
Effect of different methods of weed control on percentage seedlings emergence in the field for okra seeds harvested at different seed growth stages

Treatment	Days after flowering					
	20	25	30	35	40	
Manual weeding	25 a	55 a	60 a	67 a	58a	
Herbicide†	17 b	43 b	53 a	64 a	54a	
No weeding‡	5 c	27 c	38 b	45 b	28 b	

Means followed by the same letter are not significantly different as determined by Duncan's Multiple Range Test ($P=0.05$).

† Weeds were sprayed with Gramoxone at 14 DAP and every 21 days thereafter.

‡ Weeds were allowed to grow freely.

coverage was >10%. The reduction in seed size among the three treatments appeared to be due to the differences in the rate of accumulation of seed dry weight (g day⁻¹), especially during the first 35 DAF. Smaller initial seed size for herbicide and no weeding treatments may be due to the reduction in plant growth and development which subsequently affected assimilate supply to the developing seeds. This suggests that weed coverage of >10% will initially influence plant growth and development, affecting assimilate supply, reducing the rate of accumulation of seed dry weight to the developing seeds, and hence result in small seed size.

The presence of weeds during seed production had little effect on the developing seed to attain maximum accumulation of seed dry weight which occurred at 35 DAF. This indicates that the presence of weeds did not affect the duration for seeds to reach physiological maturity (maximum accumulation of seed dry weight). Similarly, additional gain in seed weight has no beneficial effect in seed quality. The presence of weeds also did not affect the seed from attaining its maximum germination (laboratory) potential at 30 DAF and maximum vigour level as measured by field emergence, which occurred 5 days after the seed had reached its maximum germination. Thus, it also indicates that additional gain in seed weight has no beneficial effect on seed quality. Similar observations where maximum germination occurred prior to maxi-

mum vigour level had been reported in carrot (Pollock and Roos, 1972), soybean (Miles, 1985; Puteh, 1993) and rice (Ellis *et al.*, 1993).

Germination was $\leq 25\%$ when 40-45% of the maximum seed dry weight had been accumulated. At 30 DAF, seeds have accumulated approximately 90% of their maximum dry weight for all weed control treatments and reached maximum germination potential. However, percent germination (laboratory) and field emergence for both herbicide and no weeding treatments was lower than the manual weeding treatment. Therefore, the reduction in germination (laboratory) and field emergence of harvested seeds for herbicide and no weeding treatments was due to small seed size. The effect of seed size on germination has also been reported in wheat (Whittington, 1973) and sugar beet (Scott and Longden, 1973). The decline in germination and field emergence for seeds harvested at 40 DAF was due to field weathering (deterioration process of mature seeds on plants in the field due to adverse climatic conditions) rather than the presence of weeds during production.

CONCLUSIONS

The reduction in germination and field emergence for seeds harvested from plots with $>10\%$ weed coverage was due to small seed size, and not due to the direct effect of weeds. However, the presence of weeds directly affected yield components and rate of accumulation of seed dry weight.

The presence of weeds did not affect the duration for seeds to reach physiological maturity (maximum accumulation of seed dry weight). Germination and field emergence declined when seeds were harvested at approximately 1 week after reaching its maximum vigour level at 35 DAF. Therefore, high quality okra seeds can be produced by harvesting at 35 DAF (physiological maturity).

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