# Appraisal of Species-wise Weed Distribution and Critical Period of Weed Competition in Sorghum at Kolladiba, North Gondar

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**Abstract**

A field experiment was conducted to appraise the species-wise weed distribution and critical period of weed competition in sorghum fields in Kolladiba, North Gondar, under rainfed condition during 2002. A total of 15 treatments comprising 7 increasing weed-free (WF) periods, 7 increasing weed-infestation (WI) periods and a farmers' practice were used. Fifteen weeds were observed, ten monocotyledonous and five dicotyledonous. Monocotyledonous weeds (91.6%) were dominant. The density, fresh weight and dry weight of composite weeds decreased gradually and significantly as WF period increased and increased as WI period increased. When sorghum was grown under season-long WI, its flowering was delayed by a maximum of 9 days and its maturity by 6 days. Sorghum plant population, plant height, head length, number of tillers and biomass decreased with increasing density, fresh weight and dry weight of weeds. A grain yield of 89.70% was gained from WF period of upto 60 days after emergence (DAE) and 90% from WI period of upto 30 DAE. On the basis of a 1% maximum tolerable loss of grain yield for farmers in Ethiopia, the critical period of weed competition in sorghum was 30–60 DAE.

Key words: Sorghum, weed distribution, weed competition, Gondar (Ethiopia)

## Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) is an important crop in Ethiopia that ranks third in acreage, following tef and maize. Several weeds infest the crop in Ethiopia. These include *Commelina benghalensis* Rott., *C. sabulata* Rott., *Cyperus esculentus* L., *C. rotundus* L., *Datura stramonium* L., *Digitaria scalarum* (Schweinf.) Chiov., *Eleusine africana* Pers., *E. indica* (L.) Gaertn., *Flaveria trinervea* (Spreng.) C. Mohr., *Galinsoga parviflora* Cav., *Guizotia scabra* (Vis.) Chiov., *Gynandropis gynandra* (L.) Briq., *Setaria verticillata* (L.) P. Beauv. (Rezene 1985) and *Parthenium hysterophorus* L. (Tamado and Milberg 2000).

The annual yield loss caused by weeds in Ethiopia is not less than 30% (Fasil and Giref 1997). Akobundu (1980) reported that farmers in Ethiopia spend 39% of their time on weeding. Knowledge of the species-wise dominance and the devastating effect of weeds on crops is highly required for establishing a sound weed management practice. Equally important is the critical period of weed competition which varies across crops and locations (Zimdahl 1993) and even cropping seasons.

In the North Gondar area, sorghum is grown as a rainfed crop and farmers hardly weed sorghum fields in time. In most cases, farmers in these areas perform weeding only once about 55 days after emergence (DAE) of sorghum plants; i.e., after weeds have established and already caused considerable damage to the crop (DWAO 2001). However, to effectively reduce weed competition in sorghum and thereby increase the yield of the crop, the farmers should practice their minimum weed control measure during the critical period of weed competition in sorghum fields. Therefore, the current study was conducted to appraise the species-wise

## Materials and Methods

The experiment was conducted in the 2002 cropping season on sorghum fields in Kolladiba area under rainfed condition Kolladiba is located in North Gondar, Amhara Regional State. The seasonal rainfall was 1021.2 mm and the soil type Vertic. A total of 15 treatments consisting of 7 weed-free (WF) periods, 7 weed-infestation (WI) periods and a farmers' practice (FP) were used. The WF and WI periods were for WF and WI condition for the initial 1, 15, 30, 45, 60, 75 and 90 days after emergence (DAE) of sorghum. The WF treatments were coded as $WF_0$, $WF_{15}$, $WF_{30}$, $WF_{45}$, $WF_{60}$, $WF_{75}$, $WF_{90}$ ; while the WI treatments were coded as $WI_0$, $WI_{15}$, $WI_{30}$, $WI_{45}$, $WI_{60}$, $WI_{75}$, and $WI_{90}$. A randomized complete block design with three replications was used. In farmers' practice, weeds were allowed to grow with sorghum till 55 DAE and then weeding was done once by slashing the weed plants.

Each plot consisted of 5 rows with a spacing of 75 cm between rows and 20 cm between plants. The gross plots were 5.0 m x 3.75 m and net plots 4.20 m x 2.25 m. Two seeds of sorghum variety Asham Domoze per hill were drilled in rows 20 cm apart and later thinned to one plant per hill. A mixture of 100 kg diammonium phosphate (DAP) and 100 kg urea per hectare was applied uniformly to all plots at planting.

Weed samples of increasing WI and WF treatments were used to evaluate weed species distribution, density, and fresh and dry weights. A quadrat (0.5 m × 0.5 m) was thrown randomly at three sites in each plot and weeds were sampled at the initial weed control period in case of increasing WI plots and at crop maturity in case of increasing WF. Black spot near the base of sorghum seeds indicated physiological maturity. Sorghum plant height, number of tillers, head length and total biomass weight per plant were determined based on a random sample of 10 plants. Sorghum grain yield was obtained from the net plot. The threshold point and duration of critical period were determined as per Singh et al. (1996). Data were analysed using MSTAT C statistical software package and mean separation was made by least significance difference (LSD) at 5% level (Gomez and Gomez 1984).

## Results and Discussion

### *Species-wise weed distribution*

A total of 15 weed species were observed growing in the experimental sorghum fields of increasing weed-free (WF) and weed-infestation (WI) periods. Among the weed species, 10 were monocotyledonous and 5 dicotyledonous. The monocotyledonous weed species were *Agrostis stolonifera* L., *Brachiaria eruciformis* (J.E.S.M.) Griseb., *Commelina sabulata* Rott., *Cyperus esculentus* L., *Cynodon dactylon* (L.) Pers., *C. rotundus L.; Dinebra retroflexa* (Vahl.), *Digitaria ternate* (A. Rich.) Stapf., *D. sanguinalis* (A.Rich) Stapf., and *Echinochloa colona* (L.) Link. The dicotyledononous weeds were *Cleome monophylla* L., *Hygrophila auriculata* (Schum) Heine., *Leucas martinicensis* (Jacq.) Ait. f., *Guizotia scabra* L. and *Sonchus asper* (L.) Hill. The species-wise distribution of the weeds is presented in Table 1.

*D. retroflexa* was the most dominant among the monocotyledonous as well as all the other weeds. Whereas, *C. monophylla* was the most dominant among the dicotyledonous weeds. Monocotyledonous weeds (91.6% of the total weed population) dominated dicotyledonous weeds. In most of the increasing WI treatments, *D. retroflexa*, C. *sabulata, C. rotundus* and *B. eruciformis* constituted a great proportion of abundance. The species also had a similarly greater proportion in all the increasing WF period treatments (Table 1) except *C. sabulata*, which was absent in some of the WF treatments like $WF_{30}$, $WF_{45}$, $WF_{60}$, $WF_{75}$ and $WF_{90}$. The emergence of *C.*

Table 1. Species-wise density of weeds observed in sorghum fields under increasing weed-free and weed-infestation periods after emergence of sorghum plants at Kolladiba, North Gondar, 2002

| Weed species | Weed plants ($no/m^2$ by treatments (WF or WI for initial no. of DAE and FP[1])) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 days | | 15 days | | 30 days | | 45 days | | 60 days | | 75 days | | 90 days | | FP[2] |
| | WF | WI | WF | WI | WF | WI | WF | WI | WF | WI | WF | WI | WF | WI | WI |
| **MONOCOTYLEDONOUS WEEDS** | | | | | | | | | | | | | | | |
| *Dinebra retroflexa* | 52 | -* | 43 | 9 | 33 | 86 | 19 | 45 | 14 | 90 | - | 87 | 4 | 88 | 98 |
| *Commelina sabulata* | 20 | - | 4 | 37 | - | 61 | - | 116 | - | 62 | - | 72 | - | 86 | 92 |
| *Cyperus rotundus* | 8 | - | 15 | 5 | 11 | 39 | 8 | 31 | 12 | 32 | 4 | 44 | 4 | 8 | 9 |
| *Brachiaria eruciformis* | 19 | - | 3 | - | 13 | 5 | 5 | 33 | - | 29 | 5 | 32 | 5 | 21 | 19 |
| *Digitaria ternate* | 1 | - | - | - | - | 13 | - | 4 | - | 13 | 4 | 20 | - | 11 | 16 |
| *Agrostis stolonifera* | 16 | - | 8 | - | 13 | 23 | 5 | 7 | 3 | 31 | 3 | - | 7 | 5 | - |
| *Echinochloa colona* | - | - | 7 | - | - | 3 | - | - | - | - | - | - | - | 3 | - |
| *Cynodon dactylon* | - | - | 0.4 | 2 | - | - | - | - | - | - | - | - | - | - | - |
| *C. esculentus* | - | - | - | - | - | 11 | - | 5 | - | 6 | - | - | - | - | - |
| *D. sanguinalis* | 1 | - | - | - | 4 | - | - | - | - | - | 7 | - | 7 | - | - |
| Total | 116 | - | 79 | 52 | 74 | 241 | 37 | 241 | 29 | 263 | 23 | 254 | 27 | 222 | 234 |
| **DICOTYLEDONOUS WEEDS TOTAL** | | | | | | | | | | | | | | | |
| *Cleome monophylla* | 10 | | 4 | - | 9 | 3 | 5 | - | 7 | - | 6 | - | 4 | 2 | 15 |
| *Hygrophila auriculata* | - | - | - | - | - | - | - | - | - | - | - | - | - | 5 | - |
| *Leucas martinicensis* | - | - | - | - | - | - | - | - | - | 16 | - | 1 | - | 1 | - |
| *Guizotia scabra* | - | - | - | - | - | - | - | - | - | - | - | - | - | 7 | 12 |
| *Sonchus asper* | 4 | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| Total | 14 | - | 5 | - | 9 | 3 | 5 | - | 7 | 16 | 6 | 1 | 4 | 15 | 27 |
| %monocotyledonous weeds | 89 | - | 94 | 100 | 89 | 99 | 87 | 100 | 81 | 94 | 78 | 99 | 87 | 94 | 90 |
| % dicotyledonous weeds | 11 | - | 6 | - | 11 | 1 | 12 | - | 19 | 6 | 21 | 0.5 | 13 | 6 | 10 |

[1] WF, weed-infestation treatment; WI, 1 weed-infestation treatment; DAE, days after emergence; FP, Farmers' practice
[2] FP done once 55 DAE by slashing with sickle
* weed plants not observed

*sabulata* was restricted in the early stage of sorghum growth between 15 and 30 DAE.

The emergence of *C. monophylla*, on the contrary, was probably late beyond 75 DAE since $WI_{15}$, $WI_{45}$, $WI_{60}$ and $WI_{75}$ did not have a single plant of it even though weeds were sampled from 9 quadrat areas per treatment, i.e., 3 quadrats per replication.

### *Density, fresh and dry weight of composite weeds*

There was a gradual decline in the population of composite weeds from $WF_0$ to $WF_{75}$ as the length of WF period increased (Table 2). The WF period for the initial 90 days ($WF_{90}$) had a little higher but comparable population with $WF_{75}$. However, in treatments that had increasing period of WI, there was an increment of weed population from $WI_0$ to $WI_{60}$, and then decrement in $WI_{75}$ and $WI_{90}$ (Table 2). However, the decrement or increment was not statistically significant across $WI_{30}$–$WI_{90}$.

The weedy check ($WF_0$) had significantly higher composite weed dry weight than WF30–$WF_{90}$ and $WI_0$–$WI_{45}$. The WF treatment for the initial 15 days ($WF_{15}$), $WI_{60}$, $WI_{75}$, $WI_{90}$ and FP (farmers' practice) were, however, comparable with the weedy check ($WF_0$). Whereas, $WI_{75}$ and $WI_{90}$ had higher weed dry weight than $WF_0$.

The increasing WF periods recorded lower fresh weight and dry weight than their respective increasing WI periods. This result is quite natural in a crop–weed eco-system. It corroborates the fact that weed competition is more severe at the early stage of crop growth. Singh et. al. (1996) reported a similar result.

Table 2. Density, fresh weight and dry weight of composite weeds and days to 50 % flowering, days to 50 % maturity and plant height of sorghum as affected by increasing weed-free and weed-infestation periods

| Treatment[1] | Weed density (no./m²) | Weed fresh weight (g/m²) | Weed dry weight (g/m²) | 50% flowering (days) | 50% maturity (days) | Plant height (cm) |
|---|---|---|---|---|---|---|
| $WF_0$ | 129 | 342 | 259 | 133 | 197 | 1.8 |
| $WF_{15}$ | 85 | 281 | 199 | 130 | 195 | 1.9 |
| $WF_{30}$ | 84 | 212 | 148 | 125 | 194 | 2.3 |
| $WF_{45}$ | 43 | 76 | 53 | 126 | 195 | 2.4 |
| $WF_{60}$ | 35 | 64 | 42 | 125 | 195 | 2.5 |
| $WF_{75}$ | 29 | 65 | 44 | 124 | 193 | 2.6 |
| $WF_{90}$ | 31 | 56 | 39 | 124 | 191 | 2.6 |
| $WI_0$ | 0 | 0 | 0 | 124 | 191 | 2.6 |
| $WI_{15}$ | 52 | 52 | 5 | 126 | 193 | 2.5 |
| $WI_{30}$ | 243 | 493 | 96 | 124 | 193 | 2.4 |
| $WI_{45}$ | 241 | 878 | 128 | 126 | 194 | 2.0 |
| $WI_{60}$ | 279 | 1000 | 178 | 128 | 194 | 2.0 |
| $WI_{75}$ | 256 | 1402 | 284 | 129 | 194 | 2.1 |
| $WI_{90}$ | 238 | 2039 | 383 | 129 | 196 | 2.0 |
| Farmers' practice (FP)[2] | 261 | 1354 | 199 | 128 | 195 | 2.0 |
| LSD (P= 0.05) | 55.793 | 482.018 | 80.478 | 4.29 | 2.20 | 0.24 |

[1] $WF/WI_0$ to $WF/WI_{90}$ — increasing WF (weed-free) or WI (weed-infestation) period (no. of days after emergence of sorghum plant)
[2] Weeding done once 55 days after emergence of sorghum plant by slashing weeds with sickle

Merely the duration/time of weeds' presence with sorghum played a role. Otherwise, weed species were more or less similar across the treatments.

The increasing WF period treatments ($WF_{15}$–$WF_{90}$) recorded lower weed fresh weight than the corresponding increasing WI period treatments ($WI_{15}$–$WI_{90}$). In the increasing WF period treatments, weeds were sampled at crop harvesting when a majority of weed species were matured and a bit dried. As a result, there was no much difference between fresh and dry weight of weeds.

In the increasing weed-infestation period treatments, on the contrary, there was a big difference between fresh and dry weight even within a treatment. The fresh weight remained proportionately higher and a big difference existed between the respective fresh and dry weight of weeds.

### *Sorghum phenology and growth*

An increasing period of initial weed infestation delayed the flowering and maturity and decreased the plant height of sorghum (Table 2). Whereas, an increasing period of initial weed-free situation hastened the flowering and maturity and increased the plant height of sorghum. Sorghum flowered (124 days) and matured (191 days) earlier in $WI_0$ (weed-free check) than $WF_0$ (weedy check). Flowering was also significantly earlier in $WF_{30}$–$WF_{90}$ and $WI_0$–$WI_{60}$ treatments than $WF_0$. Increasing weed competition (higher density, fresh weight and dry weight) prolonged the phenologies and a large variation in days to flowering and maturity existed due to variable duration of association of weeds with sorghum. Mengistu (1998) reported a similar result.

Table 3. Plant population, number of tillers, head length, total biomass and grain yield of sorghum as affected by composite weeds growing for different duration with sorghum

| Treatment[1] | Plant stand per net plot | Number of tillers/plant | Head length (cm) | Total biomass (g/pl) | Grain yield (kg/ha) | Yield loss (kg/ha) | Yield loss (%) |
|---|---|---|---|---|---|---|---|
| $WF_0$ | 65 | 0.2 | 19 | 46 | 815 | 1214 | 60 |
| $WF_{15}$ | 72 | 0.3 | 19 | 72 | 998 | 1031 | 51 |
| $WF_{30}$ | 77 | 0.3 | 22 | 76 | 1498 | 531 | 26 |
| $WF_{45}$ | 78 | 0.3 | 22 | 88 | 1654 | 375 | 18 |
| $WF_{60}$ | 74 | 0.3 | 24 | 101 | 1820 | 209 | 10 |
| $WF_{75}$ | 75 | 0.3 | 26 | 107 | 1882 | 147 | 7 |
| $WF_{90}$ | 75 | 0.3 | 27 | 105 | 1816 | 213 | 10 |
| $WI_0$ | 90 | 0.4 | 270 | 110 | 2029 | 0 | 0 |
| $WI_{15}$ | 85 | 0.4 | 23 | 103 | 1894 | 135 | 66 |
| $WI_{30}$ | 80 | 0.4 | 23 | 95 | 1834 | 195 | 10 |
| $WI_{45}$ | 80 | 0.3 | 24 | 81 | 1474 | 556 | 27 |
| $WI_{60}$ | 65 | 0.2 | 21 | 66 | 1321 | 709 | 35 |
| $WI_{75}$ | 70 | 0.8 | 21 | 63 | 1452 | 577 | 28 |
| $WI_{90}$ | 67 | 0.3 | 22 | 65 | 1443 | 586 | 29 |
| Farmers' practice[2] | 69 | 0.3 | 21 | 60 | 1254 | 775 | 38 |
| LSD (P=0.05) | 7.91 | 0.092 | 3.06 | 22.48 | 382.03 | | |

[1] WF/$WI_0$. to WF/$WI_{90}$ — increasing WF (weed-free) or WI (weed-infestation) period (no. of days after emergence of sorghum plant)
[2] Weeding done once 55 days after emergence of sorghum plant by slashing weeds with sickle

The plant heights recorded in $WI_0$ (2.65 m), $WF_{75}$ (2.65 cm) and $WF_{90}$ (2.62 m) were significantly greater than the values in $WF_0$, $WF_{15}$, $WF_{30}$, $WI_{45}$, $WI_{60}$, $WI_{90}$ and farmers' practice. Initial weed competition for increasing periods was responsible for the gradual decrease in sorghum height in the weed-infestation period treatments (Table 2). Whereas, the gradual increase in sorghum height in the weed-free period treatments was mainly due to gradual reduction of initial weed competition. In agreement with the present findings, Taye (1995) reported that wheat plant height at lower weed density (5–20 seedlings/$m^2$) did not differ significantly from weed-free check, while it was significantly affected at higher density (>20 seedlings/$m^2$).

### *Sorghum yield components and yield*

Sorghum plant population was significantly higher in $WF_{30}$–$WF_{90}$ and $WI_0$–$WI_{45}$ than in $WF_0$ (Table 3). That could result from weed competition for varying period. In general the number of tillers per sorghum plant was lower irrespective of all treatments. The result could be attributed to the trait of the sorghum variety Asham Domoze as it did not have much tillering capacity like other varieties of sorghum.

However, tillers/plant were significantly reduced in $WF_0$–$WF_{60}$, $WI_{45}$–$WI_{90}$ and farmers' practice than in the weed-free check ($WI_0$). Wilson and Peters (1982) reported a similar reduction in the number of fertile tillers as well as grain yield of barley due to competition by wild oats. Sorghum head length decreased significantly from 27 cm in the weed-free check ($WI_0$) to 18.56 cm in $WF_{15}$ and 18.73 cm in $WF_0$ (weedy check).

Sorghum above-ground biomass/plant and grain yield (Table 3) followed almost a similar trend. In agreement to this, many authors reported that the yield components most reduced by weed competition were plant population (Bitew 2001), number of heads/plant (Burnside and Wicks 1967), panicle size (Vesecky et al. 1973) and number of seeds per head (Feltner et al. 1969). Sorghum grain yield loss in $WI_{45}$–$WI_{90}$, $WF_0$–$WF_{30}$ and farmers' practice (Table 3) was to the tune of 26–60 % compared to weed-free check ($WI_0$).

A similar reduction has been reported by some studies (Vesecky et al. 1973; Singh et. al. 1996). Vesecky et. al. (1973) even predicted much higher yield loss under extreme condition. In Ethiopia, 42.3% sorghum yield loss due to weeds has been reported (Rezene 1985). Weeds' presence in the initial 4, 8 and 12 weeks after emergence of sorghum plant resulted in 26%, 30% and 29% yield reduction, respectively.

### *Critical period of weed competition*

A 90% minimum acceptable gain of grain yield or a 10% maximum acceptable loss of yield (Figure 1) was used as the basis for determining critical period of weed competition. Any loss exceeding 10% was considered as a serious loss to farmers in Ethiopia (Parker 1970). The grain yield gains from weed-free period of upto 60 DAE (89.7) and weed-infestation period of upto 30 DAE (90.4%) were closer to the 90% acceptable yield gain. The yield loss was about 10%. Hence, the most critical period of weed competition in sorghum was found to be 30–60 DAE, and the duration was 30 days.

The current findings however, differed slightly from Stroud (1989) who reported that the most critical periods for weed competition

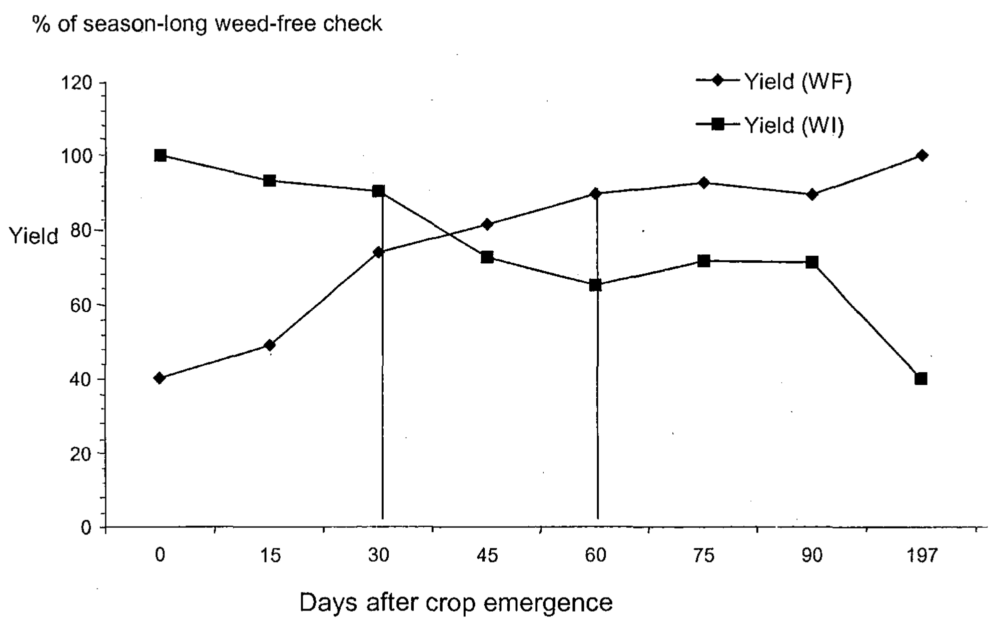


Fig. 1. Influence of varying weedy (WI) and weed-free (WF) periods on grain yield of sorghum and determination of critical period of weed competition

were 10–30 DAE or until sorghum reaches 15 cm in the drier areas and 10–15 DAE until just before flowering in the wetter and colder areas of Ethiopia. Varying environment and species diversity, density and growth of weeds and even the year of experimentation (Zimdahl 1993) might have been responsible. A similar observation made by Tamado and Milberg (2000) revealed that the critical period for parthenium control in sorghum varied across years and places in eastern Ethiopia with the greatest range being from emergence of sorghum to 66 DAE. The present study was, however, in agreement with Enyib (1973) in Tanzania and Yadav et al. (1998) in India.

## Conclusion

In the current study, 15 weed species were observed to be growing in sorghum fields under increasing weed-free and increasing weed-infestation conditions. Of these, 10 were monocotyledonous and 5 dicotyledonous weeds.

*D. retroflexa* was the most abundant species among the monocotyledonous weeds and *C. monophylla* among the dicotyledonous weeds. *D. retroflexa*, however, was the most dominant weed irrespective of all monocotyledonous and dicotyledonous weeds. Monocotyledonous weeds accounted for 91.6% of the total weed population and thus highly dominated dicotyledonous weeds. The critical period of weed competition in sorghum at Kolladiba, North Gondar, was 30–60 DAE.

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