Effect of weed management and fertility levels on population and dry matter of weeds in summer okra [Abelmoschus esculentus (L.) Moench.] under North Gujarat conditions

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Abstract
A field experiment was carried out during summer season of 2008 on a loamy sand soil at Regional Research Station, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, District: Banaskantha (Gujarat) to study the eight weed management practices i.e., Unweeded control (Wo), Weed free (i.e., Hand Weeding at 20, 40 and 60 DAS) (Wi), Hand weeding at 20 and 40 DAS (W2), Interculturing at 20 and 40 DAS (W3), Pre-emergence application of Pendimethalin @ 1.0 kg a.i./ha (Blanket application) (W4), W4 + Interculturing at 20 DAS (W5), W4 + Interculturing at 40 DAS (W6) and W4 + Hand Weeding at 40 DAS (W7) along with two fertility levels i.e., 75% recommended dose of NPK (i.e., 112.5 - 37.5 - 37.5 NPK kg/ha) (F1) and 100% recommended dose of NPK (i.e., 150 - 50 - 50 NPK kg/ha) (F2) on okra [Abelmoschus esculentus (L.) Moench.] crop. Results shows that the weeds population at 20 and 40 DAS were found significantly lowest under treatment (W7) i.e., pre-emergence application of pendimethalin @ 1.0 kg a.i./ha (W4) + Hand Weeding at 40 DAS (3.20, 2.75, 2.99 and 5.07 per m²) and (W7) i.e., pre-emergence application of pendimethalin @ 1.0 kg a.i./ha (W4) + interculturing at 20 DAS (2.84, 2.72, 2.58 and 4.60 per m²), respectively. Besides providing weed free condition through the season Hand weeding at 20, 40 and 60 DAS was found more effective in recording the less dry weight of weeds (37.87 g/m² and 230 kg ha⁻¹) as well as higher weed control efficiency (82.04 and 77.03%). Hand weeding at 20 and 40 DAS and pre-emergence application of pendimethalin @ 1.0 kg a.i. ha⁻¹ + H.W. at 40 DAS were found at par with this respect.

Keywords: Pendimethalin, hand weeding, interculturing, weed population, weed dry matter and weed control efficiency

Introduction
Okra [Abelmoschus esculentus (L.) Moench.] belongs to the family Malvaceae, is one of the important vegetable crop of subtropical and tropical regions. It is widely grown all over India for its immature tender fruits, which are used as vegetable in a variety of ways. The roots and stems of okra are used for clearing the cane juice in the manufacture of jaggery and sugar as a organic bleaching agent (Chauhan, 1972 and Singh, 1988) [2, 8]. Weed management is one of the most serious problems in modern intensive farming, as the total loss of crop yield, increased cost of cultivation would cause a greater economic loss. Weeds always offer severe competition with crop in early stage of crop growth and cause considerable reduction in the crop yield. Crop yield losses due to weeds have been estimated to the tune of 49 to 100 per cent (Singh et al., 1982; Tiwari et al., 1985 and Adejonwo et al., 1991) [7, 10, 1].

Materials and Methods
A field experiment was conducted during summer season of the year 2008 with okra crop (cv. Parbhani Kranti) at Regional Research Station, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, The soil of the site had the characteristics as follows, well drained, loamy sand, sand 85.34%, silt 8.19%, clay 6.47%, pH 7.7, EC 0.07 dSm⁻¹ and Organic carbon 0.15%. Available Nitrogen 138 kg ha⁻¹, Available phosphorus 22 kg ha⁻¹ and Available potassium 279 kg ha⁻¹. The included eight weed management practices i.e., Unweeded control (Wo), Weed free (i.e., Hand Weeding at 20, 40 and 60 DAS) (Wi), Hand weeding at 20 and 40 DAS (W2), Interculturing at 20 and 40 DAS (W3), Pre-emergence
application of Pendimethalin @ 1.0 kg a.i./ha (Blanket application) (W₃), W₄ + Interculturing at 20 DAS (W₅), W₆ + Interculturing at 40 DAS (W₇) and W₄ + Hand Weeding at 40 DAS (W₈) along with two fertility levels i.e., 75% recommended dose of NPK (i.e., 112.5-37.5-37.5 NPK kg/ha) (F₁) and 100% recommended dose of NPK (i.e., 150-50-50 NPK kg/ha) (F₂) in a Randomized Block Design with factorial concept with four replications. Application rate of N, P₂O₅ and K₂O (kg ha⁻¹) were supplied through Urea, DAP and MOP. A common seed rate of 10 kg ha⁻¹ was used. The rainfall was received during crop season was 500 mm in 23 rainy days during 2008. Weed population counts were taken by placing an iron quadrat at random measuring 1.0 square metre area in each net plot at 20 and 40 DAS. The number of monocots, dicots and sedges, falling within the quadrate were counted separately and recorded. The weed samples were collected at 60 and 80 DAS in each plot from 1.0 m² area and expressed as g/m² and kg ha⁻¹. These samples were sun-dried and then finally dried in the electrical oven at 60°C for 48 hours. The dry weight was recorded when samples attained a constant weight.

Weed control efficiency
The weed control efficiency was calculated by using the following formula.

\[ \text{WCE} = \frac{\text{DWC} - \text{DWT}}{\text{DWC}} \times 100 \]

Where, DWC and DWT were the weed dry weight in control and treated plots, respectively.

Other agronomic practices were carried out as and when required as per recommendation.

Results and discussion
Effect on monocot weed population at 20 and 40 DAS
A perusal of data presented in table 1 revealed that significantly the lowest monocot weed population at 20 DAS was noted with treatment W₇ i.e., W₄ + Hand Weeding at 40 DAS (3.20 per m²) but it was also found at par with treatment W₆ i.e., W₄ + Interculturing at 20 DAS (3.23 per m²), W₅ i.e., W₄ + Interculturing at 40 DAS (3.26 per m²) and W₄ i.e., pre-emergence application of pendimethalin @ 1.0 kg a.i./ha (Blanket application) 3.27 per m², respectively. The less monocot weed count at 20 DAS was observed due to herbicidal effect on weeds. These results are in close proximity with finding of Vashistha et al. (1974), Kumar and Choudhary (2004) [3].

At 40 DAS (Table 2) indicated that the lowest monocot weeds (2.84 per m²) were noted under pre-emergence application of pendimethalin @ 1.0 kg a.i./ha + Inter culturing at 20 DAS (W₅) but it was found at par with treatments W₇ (H.W. at 20, 40 and 60 DAS) and W₈ (H.W. at 20 and 40 DAS). Lower monocot weed population was found in these treatments due to effective control of weeds by pendimethalin and hand weeding and interculturing. In addition to this dense crop canopy might have and smothering effect on weeds. These findings corroborate the results reported by Vashistha et al. (1974), Sainbhi et al. (1994), Kumar and Choudhary (2004) [3].

Effects on dicot weed population at 20 and 40 days after sowing
A perusal of data presented in Table 1 & 2 revealed that significantly the lowest dicot weed population at 40 DAS was noted with treatment W₇ i.e., W₄ + Hand Weeding at 40 DAS (2.75 per m²), but it was also found at par with treatment W₅ i.e., W₄ + Interculturing at 20 DAS (2.77 per m²), W₆ i.e., W₄ + Interculturing at 40 DAS (2.84 per m²) and W₄ i.e., pre-emergence application of pendimethalin @ 1.0 kg a.i./ha (Blanket application) 2.85 per m², respectively. The lower dicot weed counts at 20 DAS was observed due to herbicidal effect on weeds. The highest dicot weeds (5.56 per m²) was observed under treatments W₀ (Unweeded control). It was due to absence of herbicidal application and hand weeding till 20 DAS. These results are in close vicinity with the findings of Vashisth et al. (1974), Sainbhi et al. (1994), Kumar and Choudhary (2004) [3].

Effect on sedge weeds population at 20 and 40 days after sowing
A perusal of data presented in Table 1&2 revealed that significantly the lowest sedge weed population at 20 DAS was noted with treatment W₇ i.e., W₄ + Hand Weeding at 40 DAS (2.99 per m²), but it was also found at par with treatment W₆ i.e., W₄ + Interculturing at 40 DAS (3.02 per m²), W₅ i.e., W₄ + Interculturing at 20 DAS (3.03 per m²) and W₄ i.e., pre-emergence application of pendimethalin @ 1.0 kg a.i./ha (Blanket application) 3.04 per m², respectively. This might be due to the effective weed control at early stage of crop growth by herbicidal application.

At 40 DAS (Table 2) indicated that the lowest sedge weeds (2.58 per m²) were recorded under pre-emergence application of pendimethalin @ 1.0 kg a.i./ha + Interculturing at 20 DAS (W₅) but it was found at par with treatment W₇ (H.W. at 20, 40 and 60 DAS) and W₈ (H.W. at 20 and 40 DAS) over W₀ (unweeded control). The lowest dicot weeds (2.72 per m²) were observed under pendimethalin treated condition at this stage of crop growth due to complete elimination of weeds by herbicide. The findings are also in accordance with those reportedly are Vashishtha et al. (1974), Sainbhi et al (1994), Kumar and Choudhary (2004) [3].

Effect on total weed population at 20 and 40 days after sowing
A perusal of data presented in Table 1&2 revealed that significantly the lowest total weed population at 40 DAS was noted with treatment W₇ i.e., W₄ + Hand Weeding at 40 DAS (5.07 per m²), but it was also found at par with treatment W₅ i.e., W₄ + Interculturing at 20 DAS (5.13 per m²), W₆ i.e., W₄ + Interculturing at 20 DAS (5.20 per m²) and W₄ i.e., pre-emergence application of pendimethalin @ 1.0 kg a.i./ha (Blanket application) 5.21 per m², respectively. The lower total weed counts at 20 DAS was observed due to herbicidal effect on weeds. The highest total weeds (10.69 per m²) were
observed under treatments $W_0$ (Unweeded control). It was due to absence of herbicidal application and hand weeding till 20 DAS. These results are in close vicinity with the findings of Vashistha et al. (1974) [10], Saimbhi et al. (1994), Kumar and Choudhary (2004). The lowest total weeds (4.60 per m$^2$) at 40 DAS were noted with pre-emergence application of pendimethalin @ 1.0 kg a.i./ha + interculturing at 20 days after sowing ($W_3$), but it was at par with the treatments $W_1$ (H.W. at 20, 40 and 60 DAS) and $W_2$ (H.W. at 20 and 40 DAS) over $W_0$ (unweeded control). The lowest total weeds (4.60 per m$^2$) were observed under pendimethalin treated condition at this stage of crop growth due to complete elimination of weeds by herbicide. The findings are also in accordance with those reportedly are Vashistha et al. (1974) [11], Saimbhi (1994), Kumar and Choudhary (2004) [10].

**Effect on dry weight of weeds at 60 and 80 days after sowing**

Data on dry weight of weeds at 60 and 80 days after sowing are presented in Table 3 revealed that weed free treatments $W_1$ (H.W. at 20, 40 and 60 DAS) were most effective in minimizing weed infestation and recorded significantly less dry weight of weeds (37.87 g/m$^2$ at 60 DAS and 230.76 kg/ha at 80 DAS) but it was found at par with treatment $W_2$ (H.W. at 20 and 40 DAS) and $W_7$ ($W_4$ + H.W. at 40 DAS) over unweeded control ($W_0$). The combined effect of herbicide (pendimethalin) and hand weeding resulted into lower weed counts and ultimately reduced the dry weight of weeds. These findings are in close conformity with those reported by Singh and Batra (1994) [9], Patel et al. (2004) [5].

**Effect on weed control efficiency at 60 and 80 DAS**

Data on weed control efficiency at 60 DAS and 80 DAS are presented in Table 3 revealed that the highest weed control efficiency (82.04 and 77.03%) was noted under weed free treatment $W_1$ (H.W. at 20, 40 and 60 DAS), but it was found at par with treatments $W_2$ (H.W. at 20 and 40 DAS) 79.24 per cent and 73.07 per cent and $W_7$ ($W_4$ + H.W. at 40 DAS) 78.91 and 72.44 per cent, respectively over unweeded control ($W_0$). The higher weed control efficiency under treatments $W_1$, $W_2$ and $W_7$ was due to effective control of weeds from the field. The combined effect of herbicide and hand weeding resulted in remarkable less dry weight of weeds (Table 3) observed under these treatments were responsible for higher weed control efficiency. These findings are akin to report of Shaikh et al. (2002) [6] and Patel et al. (2004) [4].

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**Table 1: Weed population/m$^2$ at 20 days after sowing in summer okra cv. Parbhani Kranti as influenced by weed management and fertility levels**

| Treatment | Monocot | Dicot | Sedge | Total |
|-----------|---------|-------|-------|-------|
| **Weed management** | | | | |
| $W_0$: Unweeded control | 8.23 (67.25) | 5.56 (30.50) | 4.07 (16.12) | 10.69 (113.87) |
| $W_1$: Weed free (i.e., Hand Weeding at 20, 40 and 60 DAS) | 8.17 (66.25) | 4.76 (22.25) | 4.05 (15.96) | 10.24 (104.46) |
| $W_2$: Hand weeding at 20 and 40 DAS | 8.03 (64.00) | 5.07 (25.25) | 3.99 (15.46) | 10.25 (104.71) |
| $W_3$: Interculturing at 20 and 40 DAS | 8.04 (64.25) | 5.02 (24.75) | 3.93 (14.98) | 10.22 (103.98) |
| $W_4$: Pre-emergence application of Pendimethalin @ 1.0 kg a.i./ha (Blanket application) | 3.27 (10.25) | 2.85 (7.60) | 3.06 (8.85) | 5.21 (26.70) |
| $W_5$: $W_4$ + Interculturing at 20 DAS | 3.22 (9.91) | 2.77 (7.18) | 3.04 (8.78) | 5.13 (25.87) |
| $W_6$: $W_4$ + Interculturing at 40 DAS | 3.26 (10.17) | 2.84 (7.57) | 3.05 (8.79) | 5.20 (26.53) |
| $W_7$: $W_4$ + Hand Weeding at 40 DAS | 3.20 (9.75) | 2.75 (7.10) | 2.99 (8.45) | 5.07 (25.30) |
| S.Em.± | 1.36 | 0.67 | 0.32 | 1.74 |
| C.D. at 5% | 3.86 | 1.89 | 0.90 | 4.94 |

| Fertility levels (NPK kg ha$^{-1}$) | | | | |
| **F1**: 75% of recommended dose | 6.13 (37.11) | 4.06 (16.06) | 3.54 (12.04) | 8.13 (65.54) |
| **F2**: 100% recommended dose (i.e., 150-50-50 NPK kg/ha) | 6.23 (38.34) | 4.10 (16.32) | 3.56 (12.23) | 8.19 (66.57) |
| S.Em.± | 0.68 | 0.33 | 0.16 | 0.87 |
| C.D. at 5% | NS | NS | NS | NS |

**Note:** Data in parentheses refers to actual weed population.

**Table 2: Weed population/m$^2$ at 40 days after sowing in summer okra cv. Parbhani Kranti as influenced by weed management and fertility levels**

| Treatment | Monocot | Dicot | Sedge | Total |
|-----------|---------|-------|-------|-------|
| **Weed management** | | | | |
| $W_0$: Unweeded control | 9.95 (98.67) | 6.55 (42.48) | 6.38 (40.20) | 13.88 (181.35) |
| $W_1$: Weed free (i.e., Hand Weeding at 20, 40 and 60 DAS) | 4.92 (23.78) | 3.35 (10.78) | 3.50 (11.75) | 6.84 (46.31) |
| $W_2$: Hand weeding at 20 and 40 DAS | 4.93 (23.80) | 3.37 (10.85) | 3.51 (11.80) | 6.85 (46.45) |
| $W_3$: Interculturing at 20 and 40 DAS | 6.64 (43.67) | 5.49 (29.76) | 4.55 (20.26) | 9.68 (93.49) |
| $W_4$: Pre-emergence application of Pendimethalin @ 1.0 kg a.i./ha (Blanket application) | 6.73 (44.90) | 5.74 (25.45) | 5.54 (32.45) | 10.50 (109.89) |
| $W_5$: $W_4$ + Interculturing at 20 DAS | 2.84 (7.60) | 2.72 (6.90) | 2.58 (6.15) | 4.60 (20.65) |
| $W_6$: $W_4$ + Interculturing at 40 DAS | 6.72 (44.76) | 5.57 (30.55) | 4.37 (18.67) | 9.71 (93.98) |
| $W_7$: $W_4$ + Hand Weeding at 40 DAS | 6.72 (44.65) | 5.57 (30.55) | 4.28 (17.86) | 9.66 (93.06) |
| S.Em.± | 1.34 | 0.81 | 0.64 | 1.83 |
| C.D. at 5% | 3.80 | 2.30 | 1.82 | 3.91 |

| Fertility levels (NPK kg ha$^{-1}$) | | | | |
| **F1**: 75% of recommended dose | 6.45 (41.14) | 4.96 (24.10) | 4.50 (19.74) | 9.24 (84.95) |
| **F2**: 100% recommended dose (i.e., 150-50-50 NPK kg/ha) | 6.50 (41.82) | 5.00 (24.50) | 4.53 (20.05) | 9.26 (85.35) |
| Treatment | Weed management | At 60 DAS (g/m²) | At 80 DAS (kg/ha) |
|-----------|----------------|-----------------|-----------------|
| W₀ : Unweeded control | 210.80 | 1004.65 |
| W₁ : Weed free (i.e., Hand Weeding at 20, 40 and 60 DAS) | (82.04)* | (77.03)* |
| W₂ : Hand weeding at 20 and 40 DAS | (79.24) | (73.07) |
| W₃ : Interculturing at 20 and 40 DAS | (61.73) | (50.18) |
| W₄ : Pre-emergence application of Pendimethalin @ 1.0 kg a.i./ha (Blanket application) | (52.25) | (38.20) |
| W₅ : W₄ + Interculturing at 20 DAS | (56.89) | (46.77) |
| W₆ : W₄ + Interculturing at 40 DAS | (61.69) | (58.12) |
| W₇ : W₄ + Hand Weeding at 40 DAS | (78.91) | (72.44) |
| S.Em± | 2.93 | 16.71 |
| C.D. at 5% | 8.32 | 47.45 |

Fertility levels (NPK kg ha⁻¹)

| F₁ : 75% of recommended dose | 78.87 | 478.03 |
| F₂ : 100% recommended dose (i.e., 150-50-50 NPK kg/ha) | 93.59 | 486.89 |
| S.Em± | 1.46 | 8.35 |
| C.D. at 5% | 4.16 | NS |

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