International Journal of Agriculture Sciences
ISSN: 0975-3710&E-ISSN: 0975-9107, Volume 10, Issue 5, 2018, pp.-5329-5331.
Available online at http://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

Research Article

BIOEFFICACY ASSESSMENT OF HERBICIDES MIXTURES FOR WEED MANAGEMENT IN *KHARIF* OKRA [*Abelmoschus esculentus* L. Moench]

MATHUKIA R.K. *, SAGARKA B.K., MATHUKIA P.R., GOHIL B.S. AND PANARA D.M.

Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh, 362001, Gujarat, India
*Corresponding Author: Email-rkmathukia@jau.in

Received: March 08, 2018; Revised: March 10, 2018; Accepted: March 11, 2018; Published: March 15, 2018

Abstract- A field experiment was conducted during *kharif* season of 2015 and 2016 at Junagadh (Gujarat, India) to study the integrated weed management in okra [*Abelmoschus esculentus* (L.) Moench]. Herbicides *viz*., pendimethalin, oxyfluorfen, pre-mix pendimethalin + imazethapyr and tank-mix pendimethalin + oxyfluorfen as pre-emergence (PE), while quizalofop, imazethapyr and tank-mix imazethapyr + quizalofop as post-emergence were tested in integration with hand weeding. The pooled results over two years revealed that uncontrolled weed growth resulted in to yield loss of 70.81%. The results further showed that HW at 15, 30 and 45 DAS, pendimethalin 900 g/ha as PE *fb* HW at 40 DAS, tank-mix pendimethalin 450 g/ha + oxyfluorfen 120 g/ha as PE *fb* HW at 40 DAS, and quizalofop 40 g/ha as POE at 20 DAS *fb* HW at 40 DAS were found effective in controlling weeds by registering lower weed count, dry weight of weeds and weed index (4.68, 7.87, 12.02 and 17.74%) along with higher weed control efficiency (94.66, 93.42, 84.22 and 79.21%). These treatments also improved growth and yield attributes *viz*., plant height, number of fruits per plant, fruit length, fruit girth and fruit weight per plant, and ultimately produced higher fruit yield of okra (81.06, 78.35, 74.82 and 69.95 q/ha) over the unweeded check (24.82 q/ha).

Key words- Okra, *Abelmoschus esculentus*, Weed, Herbicide, Pendimethalin, Oxyfluorfen, Imazethapyr, Quizalofop

Citation: Mathukia R.K., *et al*., (2018) Bioefficacy Assessment of Herbicides Mixtures for Weed Management in *Kharif* Okra [*Abelmoschus esculentus* L. Moench]. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 10, Issue 5, pp.-5329-5331.

Introduction

In tropical and sub-tropical regions, okra [*Abelmoschus esculentus* L. Moench] is an important vegetable crop for its tender fruits (pods). Due to wider spacing and slow growth during initial stage as well as favourable ecological conditions for weeds, okra endures substantial yield loss in monsoon (*kharif*) season. A yield loss of about 54.1 to 90.6% has been reported in okra due to weed competition [1], depending on the type of weed flora, their intensity and stage. The most critical period of crop-weed competition in okra is 2-6 weeks after sowing. Weeds are generally controlled by physical and cultural methods, and hand weeding is the most applicable and effective method of weed control. However, these methods are tedious, time consuming and laborious. Unavailability of labour at the peak time and sometimes unfavourable field conditions do not permit manual weedings. The easiest way to control weeds is through herbicides, which is quicker and cheaper as compared to other methods. Hence, there is need to evolve weed management strategy by integrating herbicides or their mixtures with manual weeding.

Research revealed that pre-emergent herbicides *viz*., fluchloralin, pendimethalin [2,3], oxyfluorfen [4] and alachlor [5] found very effective in controlling weeds in okra. However, reports on the efficacy of post-emergence herbicides in okra are scanty. Moreover, considering the side effects of continuous use of chemicals, relying only on herbicides alone for weed management is not ideal. Hence, the present investigation was carried out to evaluate the efficacy of various herbicides and their mixtures in combination with manual weeding for managing weeds and obtaining higher yield of okra under south Saurashtra conditions.

Materials and Methods

A field experiment was conducted at Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat) during *kharif* seasons of 2015 to 2016. The soil of the experimental plot was clayey in texture and slightly alkaline in reaction as well as low in available nitrogen, available phosphorus and medium in available potash. The experiment comprising of 10 treatments *viz*., T_1: Pendimethalin 900 g/ha as pre-emergence (PE) *fb* hand weeding (HW) at 40 DAS, T_2: Oxyfluorfen 240 g/ha as PE *fb* HW at 40 DAS, T_3: Pre-mix Pendimethalin 30.24% + Imazethapyr 2.24% 900 g/ha as PE *fb* HW at 40 DAS , T_4: Tank-mix Pendimethalin 450 g/ha + Oxyfluorfen 120 g/ha as PE *fb* HW at 40 DAS, T_5: Quizalofop 40 g/ha as post-emergence (POE) at 20 DAS *fb* HW at 40 DAS, T_6: Imazethapyr 75 g/ha as POE at 20 DAS *fb* HW at 40 DAS, T_7: Tank-mix Imazethapyr 37.5 g/ha + Quizalofop 20 g/ha as POE at 20 DAS *fb* HW at 40 DAS, T_8: HW at 15, 30 & 45 DAS, T_9: Weed-free and T_{10}: Weedy check, was laid out in randomized block design with three replications. The gross and net plot size was 6.0 m x 3.6 m and 5.1 m x 2.4 m, respectively. The pre-emergence herbicides were applied to soil on next day of sowing, while post-emergence spray was done at 20 DAS. The spray volume herbicide application was 500 L/ha. The improved variety of okra 'Gujarat Junagadh Okra 3' was sown at 60 cm x 30 cm using seed rate of 8 kg/ha. A fertilizer dose of 50-50-50 N-P_2O_5-K_2O kg/ha was applied as basal at sowing and 50 kg N/ha each was top-dressed at 30 and 60 DAS. The crop was raised as per the recommended package of practices. In manual weed control treatments, weeds were uprooted and removed as per treatments. In weed free plots, the weeds were removed manually after every seven days for ensuring complete weed free condition. The biometric observations on plant height, fruits per plant, fruit length, fruit girth and fruit weight per plant were recorded from five tagged plants per plot. The number of weeds and dry weight of weeds were

recorded at harvest. The fruit yield of all the pickings were recorded from net plot. Weed index (WI) and weed control efficiency (WCE) were worked out using following formulae suggested by the research workers [6,7].

$$WI\ (\%) = \frac{Y_{WF} - Y_T}{Y_{WF}} \times 100$$

Where; Y_{WF} and Y_T are the yield from weed-free plot and yield from treated plot, respectively.

$$WCE\ (\%) = \frac{DW_C - DW_T}{DW_C} \times 100,$$

Where, DW_C = Dry matter accumulation of weeds in unweeded control, DW_T= Dry matter accumulation of weeds in treated plot.

The data were subjected to statistical analysis by adopting appropriate analysis of variance [8]. Wherever the F values found significant at 5 per cent level of probability, the critical difference (CD) values were computed for making comparison among the treatment means.

Results and Discussion

The dominant weed flora observed in the experimental field were *Echinochloa colona, Cynodon dactylon, Indigofera glandulosa, Dactyloctenium aegyptium* and *Brachiaria ramosa* among the monocots; *Digera arvensis, Commelina benghalensis, Leucas aspera, Eclipta alba, Portulaca oleracea* and *Phyllanthus niruri* among the dicot weeds, and *Cyperus rotundus* as sedge weed.

Effect on crop

Data presented in [Table-1] showed that various weed management treatments significantly influenced growth and yield attributes of okra. Significantly the highest plant height (81.17 cm) was recorded with the weed-free check (T_9), however it remained statistically at par with HW thrice (T_8), pendimethalin 900 g/ha as PE *fb* HW at 40 DAS (T_1), tank-mix pendimethalin 450 g/ha + oxyfluorfen 120 g/ha as PE *fb* HW at 40 DAS (T_4) and quizalofop 40 g/ha as POE at 20 DAS *fb* HW at 40 DAS (T_5). The weed-free check (T_9) has given significantly the highest number of fruits per plant (17.30), which remained statistically comparable to HW thrice (T_8) and pendimethalin 900 g/ha as PE *fb* HW at 40 DAS (T_1).

Table-1 *Effect of weed management on growth and yield attributes of okra (Pooled over two years)*

Treatment	Plant height (cm)	Fruits per plant	Fruit length (cm)	Fruit girth (cm)	Fruit weight per plant (g)
Pendimethalin *fb* HW	76.56	15.82	16.63	6.23	169.19
Oxyfluorfen *fb* HW	66.67	13.77	14.05	5.94	135.59
Pendimethalin + Imazethapyr *fb* HW	61.87	12.80	13.22	5.76	105.69
Pendimethalin + Oxyfluorfen *fb* HW	70.08	14.68	14.29	6.15	163.38
Quizalofop *fb* HW	67.26	14.67	14.21	6.10	145.23
Imazethapyr *fb* HW	56.81	11.85	12.72	5.64	102.14
Imazethapyr + Quizalofop *fb* HW	64.76	13.67	13.39	5.86	116.20
HW thrice	78.80	16.47	17.27	6.34	191.83
Weed-free check	81.17	17.30	17.62	6.42	202.43
Weedy check	56.52	8.48	9.91	4.55	54.68
S.Em.±	4.70	0.73	0.71	0.16	7.99
CD (P=0.05)	13.96	2.18	2.11	0.48	23.73

The fruit length was significantly highest (17.62 cm) with the weed-free check (T_9), but it was statistically equivalent to HW thrice (T_8) and pendimethalin 900 g/ha as PE *fb* HW at 40 DAS (T_1). The weed-free check (T_9) registered significantly the highest fruit girth (6.42 cm), however it was statistically at par with HW thrice (T_8), pendimethalin 900 g/ha as PE *fb* HW at 40 DAS (T_1), tank-mix pendimethalin 450 g/ha + oxyfluorfen 120 g/ha as PE *fb* HW at 40 DAS (T_4) and quizalofop 40 g/ha as POE at 20 DAS *fb* HW at 40 DAS (T_5). Significantly the maximum fruit weight per plant (202.43 g) was recorded under the weed-free check (T_9), however it remained at par with HW thrice (T_8). Among post-emergence treatments, quizalofop 40 g/ha as POE at 20 DAS *fb* HW at 40 DAS was found superior.

Efficient control of weeds by manual weeding and/or herbicides under the above superior treatments might have reduce crop-weed competition for moisture, nutrients and sunlight and ultimately enhanced photosynthetic and metabolic activities in the crop, which reflected in improved growth and development of the crop. Whereas, unrestricted weed growth under weedy check (T_{10}) restrained growth and development of the crop as evidenced from the lowest values of plant height (56.52 cm), fruits per plant (8.48), fruit length (9.91 cm), fruit girth (4.55 cm) and fruit weight per plant (54.68 g). These findings are in close conformity with previous reports [9-11]. The data furnished in [Table-2] showed fruit yield of okra significantly affected by different weed management treatments. The weed-free check (T_9) produced significantly the highest fruit yield of 85.04 q/ha. The next best treatments in this regard were HW at 15, 30 and 45 DAS(T_8) and pendimethalin 900 g/ha as PE *fb* HW at 40 DAS (T_1) with fruit yield of 81.06 and 78.35 q/ha, respectively. Among post-emergence treatments, quizalofop 40 g/ha as POE at 20 DAS *fb* HW at 40 DAS (T_4) was found superior by recording fruit yield of 69.95 q/ha. Overall, the treatments *viz*., weed-free check (T_9), HW thrice (T_8), pendimethalin 900 g/ha as PE *fb* HW at 40 DAS (T_1), tank-mix pendimethalin 450 g/ha + oxyfluorfen 120 g/ha as PE *fb* HW at 40 DAS (T_4) and quizalofop 40 g/ha as POE at 20 DAS *fb* HW at 40 DAS (T_5) increased fruit yield to the tune of 243, 227, 216, 201 and 182 per cent over the unweeded check (T_{10}). Improved growth and yield attributes owing to effective control of weeds under these treatments might have accelerated partitioning of photosynthates to various metabolic sinks and resulted in increased fruit yield. These findings are in agreement with those reported earlier [12-14].

Effect on weeds

The data [Table-2] indicated that different weed management treatments did cause significant variation in count and dry weight of weeds. The weed-free (T_9) recorded significantly the lowest weed count (3.0/m^2) and dry weight of weeds (44 kg/ha), followed by HW thrice (T_8), pendimethalin 900 g/ha as PE *fb* HW at 40 DAS (T_1), tank-mix pendimethalin 450 g/ha + oxyfluorfen 120 g/ha as PE *fb* HW at 40 DAS (T_4) and quizalofop 40 g/ha as POE at 20 DAS *fb* HW at 40 DAS (T_5) having WI of 0.00, 4.68, 7.87, 12.02 and 17.74%, and WCE of 97.98, 94.86, 93.42, 84.22 and 79.21%, respectively. Weed suppression during initial stage by hand weeding and/or pre-emergence/pre-plant pendimethalin supplemented with manual weeding or post-emergence quizalofop in the later stage provided effective control of weeds as evident from lower dry weight of weeds and excellent weed indices. Similar results have been reported erstwhile [14-16].

Table-2 *Effect of weeds management on fruit yield and weed parameters (Pooled over two years)*

Treatment	Fruit yield (q/ha)	Weed count (Nos./m^2)*	Weed dry weight (kg/ha)	Weed index (%)	Weed control efficiency (%)
Pendimethalin *fb* HW	78.35	3.48 (11.7)	143	7.87	93.42
Oxyfluorfen *fb* HW	64.02	6.20 (38.0)	546	24.72	74.89
Pendimethalin + Imazethapyr *fb* HW	45.25	4.20 (17.3)	882	46.79	59.43
Pendimethalin + Oxyfluorfen *fb* HW	74.82	5.11 (25.7)	343	12.02	84.22
Quizalofop *fb* HW	69.95	6.79 (45.7)	452	17.74	79.21
Imazethapyr *fb* HW	41.37	5.84 (33.7)	1067	51.35	50.92
Imazethapyr + Quizalofop *fb* HW	56.87	4.77 (22.3)	694	33.13	68.08
HW thrice	81.06	3.61 (12.7)	116	4.68	94.66
Weed-free check	85.04	1.86 (3.0)	44	0.00	97.98
Weedy check	24.82	9.80 (95.7)	2174	70.81	0.00
S.Em.±	2.92	0.19	41		
CD (P=0.05)	8.36	0.56	118		

**Data were subjected to square root transformation and original data given in parenthesis.*

Conclusion

On the basis of two-year field experimentation, it can be concluded that effective control of weeds in *kharif* okra along with higher fruit yield could be achieved by either of the followings:

- Hand weeding at 15, 30 and 45 days after sowing
- Pre-emergence application of pendimethalin 900 g/ha and hand weeding at 40 days after sowing
- Pre-emergence application of tank-mix pendimethalin 450 g/ha + oxyfluorfen 120 g/ha and hand weeding at 40 days after sowing
- Post-emergence application of quizalofop 40 g/ha at 20 days after sowing and hand weeding at 40 days after sowing.

Application of research: Weeds are great threat to crop production. In the present case, uncontrolled weeds caused 71% yield loss. This research is important for managing weeds in okra. The integrated approach evolved in this study resulted in effective weed control (84 to 95%) along with higher yield (182 to 227%) compared to the unweeded check.

Research Category: Biotic stress, weed management

Abbreviations
DAS: Days after sowing
PE: Pre-emergence
POE: Post-emergence
fb: followed by
WI: Weed index
WCE: Weed control efficiency

Acknowledgement: The authors acknowledge Junagadh Agricultural University, Junagadh, 362001, Gujarat, for providing funding for the experiment. We are also grateful to Director of Research and Head, Department of Agronomy, Junagadh Agricultural University, Junagadh, 362001, Gujarat, India for execution of the experiment. The help rendered by field staff of Department of Agronomy is highly appreciated.

***Principle Investigator: Dr. R. K. Mathukia**
University: Junagadh Agricultural University, Junagadh, 362001, Gujarat, India
Research project name: Weed Control Research Project, Department of Agronomy

Author Contributions
R.K. Mathukia: PI of the project, design of the experiment and interpretation, drafting the article, critical revision of the article and final approval of the version to be published.
B.K. Sagarka: Head of Department, guidance and monitoring of the project.
P.R. Mathukia: Statistical analysis and tabulation of data.
B.S. Gohil: Treatment application and data collection.
D.M. Panara: Material arrangement and field operations

Author statement: All authors read, reviewed, agree and approved the final manuscript

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

Conflict of Interest: None declared

References
[1] Singh G., Bhan V.M. and Tripathi S.S. (1982) *Indian Journal of Weed Science*, 14(1), 19-23.
[2] Patel R.B., Patel B.D., Meisuriya M.I. and Patel V.J. (2004) *Indian Journal of Weed Science,* 36(3/4), 304-305.
[3] Das T.K., Nayak P. and Sahoo S. (2001) *Orissa Journal of Horticulture*, 29(2), 113-115.
[4] Reddy M.D., Reddy C.N. and Devi M.P. (2001) *Indian Journal of Weed Science*, 33(3/4), 217-219.
[5] Jadhao B.J., Patil B.M., Karunakar A.P., Joshi P.S. and Mahorkar V.K. (2001) *Journal of Soils and Crops*, 11(1), 106-108.
[6] Gill G.S. and Kumar V. (1969) *Indian Journal of Agronomy*, 16(2), 96-98.
[7] Kondap S.M. and Upadhyay U.C. (1985) A Practical Manual of Weed Control. Oxford and IBH Publ. Co., New Delhi.
[8] Gomez K. and Gomez A. (1984) Statistical Procedures for Agricultural Research, 2nd Edition. John Willey and Sons, New York, p. 680.
[9] Singh M., Prabhukumar S. and Sairam C.V. (2010) *Annals of Plant Protection Sciences*, 18(2), 481-483.
[10] Jalendhar G. (2012) Integrated weed management in okra (*Abelmoschus esculentus* (L.) Moench) cv. Arka Anamika. M.Sc. (Agri.) thesis, Dr. YSR Horticultural University, Rajendranagar, Hyderabad.
[11] Tiwari S. (2012) Seed yield of okra (*Hibiscus esculentus* L. Moench) as influenced by integrated weed management. M.Sc. (Agri.) thesis, RVS Krishi Vishwa Vidyalay, Gwalior.
[12] Pandey V.K and Mishra A.C. (2013) Weed management technology in okra. *In*: National Symposium on Abiotic and Biotic Stress Management in Vegetable Crops. North America, March 2013.
[13] Shamla K., Sindhu P.V. and Menon M.V. (2017) *Journal of Tropical Agriculture,* 55(1), 57-62.
[14] Zinzala M.J., Patel T.U., Patel H.H., Patel D.D., Patel H.M. and Italiya A.P. (2017) *AGRES - An International e-Journal*, 6(1), 129-133.
[15] Sharma S. and Patel B.D. (2011) *Indian Journal of Weed Science,* 43(3/4), 226-227.
[16] Patel T.U., Zinzala M.J., Patel D.D., Patel H.H. and Italiya A.P. (2017) *Indian Journal of Weed Science*, 49(3), 263-265.