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# WEED SUPPRESSION, GRAIN YIELD AND ECONOMICS OF WHEAT AFFECTED BY WEED MANAGEMENT PRACTICES

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## Abstract

Herbicides application increases residual effect in the soil which affect soil quality as well as crop productivity. Considering these facts, the present investigation was carried out with objectives to reduce the amount of herbicides in wheat production. Sorghum extract and herbicide are an integrated approach for weed management. The aim of the present study is to calibrate the potential of sorghum extract on weed suppression and yield of wheat as well as to reduce the use of quantity of herbicides. Sorghum extract (1:3) + ready-mix of clodinafop + metsulfuron 64 g/ha in $T_8$ applied post-emergence significantly reduced the density of monocot weed (2.91, 2.36 and 1.88/m$^2$), dicot weed (3.11, 2.36 and 1.99/m$^2$) and significantly produced grain yield 4543 kg/ha and magnitude of enhancement were 34.87% over weedy check. The gross return (120351 Rs/ha), net return (87305 Rs/ha) and B-C ratio (3.64) were also obtained highest in $T_8$.

## Introduction

Wheat (*Triticum aestivum* L.) is a vital cereal crop. It is a key member of the Poaceae family and play a significant role in global agriculture production. Carbohydrate, protein, fat and vital amounts of vitamins and minerals are present in wheat (Patil *et al.* 2023). Wheat is grown over approximately 2.84 million hectares area, yielding 11.11 million tonnes with a productivity rate of 3913 kg per hectare. (Commissionerate of Agriculture 2022).

Among the various pests affecting wheat crops, weeds are particularly for causing significant damage during the early growth stage. Research indicates that over one-third of total yield losses was observed due to weed infestations (Hamid *et al*. 2017). Weeds, mining more nutrient results in lesser acquisition of nutrient by the crop hence, growth and yield of crop gets affected. Poor weed management practices are a major factor contributing to yield reduction in wheat (Parita and Rana 2021). Weeds are major limiting biotic factors in wheat and it reduces 17 to 30 per cent yield losses in wheat annually (Goudar *et al*. 2020). Among that, integration of non-chemical method (sorghum extract) with chemical method (herbicide) has become judicious methodology for weed management in wheat crop. Under arid conditions of Western Rajasthan, both monocot and dicot weeds are dominant. Singh and Singh (2004) from Jodhpur reported that 42.8 per cent reduction in yield of wheat crop was due to weed infestation. Early management of weeds in wheat crops increase yield by reducing crop and weeds competition. Wheat crop is infested with monocot as well as dicot weeds and cause yield loss of 7 to 50 per cent depending upon the types of weed flora and their population (Choudhary *et al*. 2016). Use of sorghum extract having good allelopathic effect may be best viable option for managing weeds at early growth stage in wheat that reduce the heavy dose of herbicides. Allelopathy is a natural phenomenon in which different

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organism affects the functioning of other organisms in their vicinity by releasing secondary metabolites negatively or positively (Afzal and Iqbal 2015) and some time it linked with abiotic stresses in plant (Bhowmick *et al.* 2024). Among various allelopathic crops, sorghum stands out due to its high number of allelochemicals, which effectively inhibit weed growth (Jabran *et al.* 2015). Phenolic, alkaloids, flavonoids, and terpenoids secondary metabolites are present in sorghum plant. Foliar application of sorghum water extract in sesame crop reduced weed density (15 to 17%) and dry weight (19 to 49%). Liquid extract of sorghum in low concentration has stimulatory effects on germination and growth of weeds. Cheema *et al*. (2020) reported that foliar spray of sorghum extract reduces weed biomass by 35 to 40 per cent and increased wheat productivity by 10 to 21%. The herbicides are not showed harmful effect when applied at recommended dose (Selvamani and Sankaran 1993) but some reports showed that herbicidal application may have harmful effect on soil properties and environment (Rajendran and Lourduraj 1999). The herbicide application may change in soil microbial activity, genetic structure and nutrient levels. The integrated weed management is crucial to improve wheat production without damaging environment. Therefore, this study was carried out to enumerate the effect of sorghum extract and herbicides on weed suppression, growth, yield and economics of wheat.

**Materials and Methods**

The analytical results showed that the soil in the experimental fields was sand-loamy in texture and slightly alkaline, with a pH of 8.2. It was non-saline, with an electrical conductivity of 0.12 dS/m. The soil had low levels of organic carbon (0.14%) and available nitrogen (177 kg/ha), but was medium in available phosphorus (22 kg/ha) and high in available potassium (330 kg/ha). The bulk density of the soil in the experimental field was 1.77 Mg/m³, while its field capacity was 13.21 per cent. Additionally, the area experiences a high potential evapotranspiration (1843 mm/year) and wide deviations in maximum (24.6$^{o}$C in January to 41.6$^{o}$C in May) and minimum (9.6 in January to 27.7$^{o}$C in June) temperature.

The experiment comprised eleven treatment combinations, *viz*, $T_1$ (Sorghum extract 1:1), $T_2$ (Sorghum extract 1:2), $T_3$ (Sorghum extract 1:3), $T_4$ (Sorghum extract 1:4), $T_5$ (Ready mix of clodinafop + metsulfuron 64 g/ha), $T_6$ (Sorghum extract 1:1) + ready-mix of clodinafop + metsulfuron 64 g/ha), $T_7$ (Sorghum extract 1:2) + ready-mix of clodinafop + metsulfuron 64 g/ha), $T_8$ (Sorghum extract 1:3) + ready-mix of clodinafop + metsulfuron 64 g/ha), $T_9$ (Sorghum extract 1:4) + ready-mix of clodinafop + metsulfuron 64 g/ha) including two checks $T_{10}$ (weed free check) and $T_{11}$ (weedy check) was reported to work out "Bio-efficacy of sorghum extract and herbicide on growth, yield and quality of wheat (*Triticum aestivum* L.)". The experiment was laid out in Randomized Block Design (RBD) with three replications during *rabi* season of (2021-22) at Instructional Farm, College of Agriculture, Jodhpur (Rajasthan) India. According to treatment *viz.* 1:1, 1:2, 1:3 and 1:4 (sorghum extract/water) dilution sprayed at 21 DAS and Clodinafop + metsulfuron 64 g/ha herbicide were applied at 30 DAS during the experimentation. The data of weed density and weed dry weight were subjected to square root transformation (x + 0.5) to normalize their distribution as per Gomez and Gomez (1984). The critical difference (CD) for the treatment comparisons was worked out where ever the variance ratio (F-test) was found significant at 5 per cent level of probability.

**Results and Discussion**

Broad leaf, grass and sedges weed flora were observed in the field experimental. Broad-leaved weeds were dominated over grassy and sedges (Table 1). Data revealed that sequential and post-emergence application of sorghum extract (1 : 3) + ready-mix of clodinafop + metsulfuron 64 g/ha ($T_8$) significantly reduced density of monocot and dicot weeds at 60, 90 DAS and at harvest followed by $T_7$ which also showed their significant effects on reducing weed density of monocot and dicot weeds at different growth stages (Tables 2 and 3). Among alone application of sorghum extract $T_3$ was found effective in reducing weed density of monocot and dicot weeds at different growth stages as compared to $T_{11}$ (Tables 2 and 3). Sorghum extract affecting several physiological processes including inhibition of nutrient uptake, mitotic inhibition, photosynthetic inhibition in weed plant (Naeem *et al*. 2018). Clodinafop-propargyl is basically *Acetyl Co-A carboxylase* (ACCase) inhibitor most effective in controlling monocot weeds in wheat. Metsulfuron-methyl is basically an *Acetolactate Synthase* (ALS) enzyme inhibitor, a enters into the plant through root as well as foliage. According to Das (2015) this inhibits the cell division and growth in the plant.

**Table 1. Major weed flora of the experimental plot observed during crop season.**

| Category of weeds | Botanical name | Family | Common name | Local name |
|---|---|---|---|---|
| BLWs | *Chenopodium murale* L. | Chenopodiaceae | Nettle-leaved goosefoot | *Khartua* |
| | *Chenopodium album* L. | Chenopodiaceae | Common lambsquater | *Bathua* |
| | *Rumex dentatus* L. | Polygonaceae | Toothed dock | *Jangali palak* |
| grass | *Asphodelus tenuifolius* L. | Liliaceae | Wild onion | *Vanpiazi* |
| Sedges | *Cyperus rotundus* L. | Cyperaceae | Purple nut sedge | *Motha* |

BLWs- Broad-leaved weeds

**Table 2. Effects of sorghum extract and herbicide on density of monocot weeds in wheat.**

| Treatments | Monocot weeds (No./$m^2$) | | | |
|---|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS | At harvest |
| $T_1$ | 4.95a<br>(24.02) | 4.63i<br>(20.97) | 4.36h<br>(18.50) | 4.14g<br>(16.62) |
| $T_2$ | 4.80a<br>(22.53) | 4.24fg<br>(17.44) | 3.94fg<br>(15.08) | 3.74e<br>(13.48) |
| $T_3$ | 4.71a<br>(21.67) | 4.13ef<br>(16.54) | 3.84ef<br>(14.27) | 3.62e<br>(12.58) |
| $T_4$ | 4.89a<br>(23.40) | 4.51hi<br>(19.84) | 4.37h<br>(18.56) | 3.95f<br>(15.11) |
| $T_5$ | 5.07a<br>(25.18) | 4.35gh<br>(18.43) | 4.07g<br>(16.08) | 3.86<br>(14.43) |
| $T_6$ | 4.95a<br>(24.04) | 3.99de<br>(15.46) | 3.65de<br>(12.85) | 3.38d<br>(10.90) |
| $T_7$ | 4.73a<br>(21.91) | 3.36c<br>(10.81) | 2.93c<br>(8.07) | 2.60c<br>(6.26) |
| $T_8$ | 4.67a<br>(21.31) | 2.91b<br>(8.01) | 2.36b<br>(5.12) | 1.88b<br>(3.10) |
| $T_9$ | 4.98a<br>(24.33) | 3.87d<br>(14.51) | 3.49d<br>(11.72) | 3.22d<br>(9.88) |
| $T_{10}$ | 0.71a<br>(0.00) | 0.71a<br>(0.00) | 0.71a<br>(0.00) | 0.71a<br>(0.00) |
| $T_{11}$ | 5.11a<br>(25.59) | 5.88j<br>(34.13) | 6.79i<br>(45.61) | 7.17h<br>(50.94) |
| SEm± | 0.10 | 0.06 | 0.08 | 0.07 |
| CD (*P*= 0.05) | NS | 0.17 | 0.23 | 0.19 |

*Data subjected to square root transformation ($\sqrt{X+0.5}$), value in parentheses represent original value.

**Table 3. Effects of sorghum extract and herbicide on density of dicot weeds in wheat.**

| Treatments | Dicot weeds (No./$m^2$) | | | |
|---|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS | At harvest |
| $T_1$ | 9.77a (94.87) | 9.17j (83.54) | 8.64j (74.16) | 7.81i (60.54) |
| $T_2$ | 8.81a (77.18) | 7.62g (57.53) | 6.85g (46.40) | 6.21g (38.11) |
| $T_3$ | 8.56a (72.76) | 7.03f (48.88) | 6.40f (40.46) | 5.60f (30.88) |
| $T_4$ | 9.07a (81.81) | 8.63i (73.93) | 7.96i (62.92) | 7.50i (55.70) |
| $T_5$ | 10.21a (103.86) | 8.15h (65.93) | 7.50h (55.71) | 7.08h (49.67) |
| $T_6$ | 9.75a (94.59) | 6.33e (39.57) | 5.69e (31.93) | 4.97e (24.23) |
| $T_7$ | 8.79a (76.68) | 4.49c (19.85) | 3.82c (14.20) | 3.48c (11.63) |
| $T_8$ | 8.50a (72.04) | 3.11b (9.23) | 2.36b (5.17) | 1.99b (3.49) |
| $T_9$ | 9.11a (82.51) | 5.50d (29.78) | 5.00d (24.56) | 4.43d (19.18) |
| $T_{10}$ | 0.71a (0.00) | 0.71a (0.00) | 0.71a (0.00) | 0.71a (0.00) |
| $T_{11}$ | 10.32a (105.91) | 10.93k (118.91) | 11.39k (129.28) | 11.97j (142.91) |
| SEm± | 0.16 | 0.12 | 0.13 | 0.12 |
| CD ($P$= 0.05) | NS | 0.35 | 0.39 | 0.35 |

*Data subjected to square root transformation ($\sqrt{X+0.5}$), value in parentheses represent original value.

Treatment $T_8$ significantly produced grain yield and followed by the treatment sprayed with slightly higher concentration *i.e.* treatment ($T_7$), and this treatment was statistically at par with treatment $T_9$ in wheat during investigation (Table 4). Sorghum extract and herbicide suppress the initial growth of weed and increase the nutrient availability by crop as well as increased metabolic functions like cell division and photosynthesis (Naby and Ali 2020). An explicit of data revealed that maximum expenditure on cost of cultivation was incurred under weed free due to more labours were deployed for keeping plot weed free over season long. Application of sorghum extract at $T_8$ recorded lowest cost of cultivation, maximum gross return, net return and achieved higher profitability level with respect to B: C ratio and showed its economic feasibility over rest of the treatments during the year of investigation (Table 4).

**Table 4. Effects of sorghum extract and herbicide on yield and economics of wheat.**

| Treatments | Grain yield (kg/ha) | Cost of cultivation (Rs/ha) | Gross return (Rs/ ha) | Net return (Rs/ ha) | B: C ratio |
|---|---|---|---|---|---|
| $T_1$ | 3392g | 33,162 | 92,457 | 59,295 | 2.79 |
| $T_2$ | 3815e | 32,492 | 1,03,147 | 70,655 | 3.17 |
| $T_3$ | 3933d | 32,162 | 1,06,203 | 74,041 | 3.30 |
| $T_4$ | 3584f | 31,962 | 97,173 | 65,211 | 3.04 |
| $T_5$ | 3726e | 31,542 | 1,00,844 | 69,302 | 3.20 |
| $T_6$ | 3999d | 34,046 | 1,07,910 | 73,864 | 3.16 |
| $T_7$ | 4217c | 33,376 | 1,12,794 | 79,418 | 3.38 |
| $T_8$ | 4543b | 33,046 | 1,20,351 | 87,305 | 3.64 |
| $T_9$ | 4116c | 32,846 | 1,10,765 | 77,919 | 3.37 |
| $T_{10}$ | 4850a | 40,738 | 1,27,369 | 86,631 | 3.13 |
| $T_{11}$ | 2959h | 30,658 | 83,016 | 52,358 | 2.71 |
| SEm± | 36.42 | - | - | - | - |
| CD ($P$= 0.05) | 107.43 | - | - | - | - |

Note: Sale price of wheat grain ` 19.75/kg and straw ` 6.00/kg in 2021-22.

**Table 5. Effects of sorghum extract and herbicide on principal component analysis of different treatments in wheat.**

| | PC Scores | | | |
|---|---|---|---|---|
| Treatments | D1 | | D2 | |
| | PC1 | PC2 | PC1 | PC2 |
| $T_1$ | -2.404 | 0.384 | -2.841 | 0.273 |
| $T_2$ | -0.258 | -0.114 | -0.289 | -0.224 |
| $T_3$ | 0.364 | -0.246 | 0.471 | -0.390 |
| $T_4$ | -1.435 | 0.155 | -1.538 | -0.135 |
| $T_5$ | -0.992 | -0.774 | -0.687 | -0.382 |
| $T_6$ | 0.346 | -0.702 | 0.595 | 0.152 |
| $T_7$ | 1.926 | -0.726 | 1.710 | -0.283 |
| $T_8$ | 3.182 | -1.170 | 3.383 | -0.598 |
| $T_9$ | 1.119 | -0.942 | 1.370 | -0.321 |
| $T_{10}$ | 4.785 | 3.003 | 3.549 | 1.531 |
| $T_{11}$ | -6.634 | 1.132 | -5.724 | 0.376 |
| Maximum | 4.785 | 3.003 | 3.549 | 1.531 |
| Minimum | -6.634 | -1.170 | -5.724 | -0.598 |

D1: The numerical score of each treatment on principal component 1 and principal component 2 during PC analysis of different characters *viz.* weed density of monocot and dicot weed at 30, 60 90 DAS and at harvest, grain yield, net return and B: C ratio

D2: The numerical score of each treatment on principal component 1 and principal component 2 during PC analysis of different characters *viz.* weed density of monocot and dicot at harvest, DMA and CGR at harvest, RGR at 90 DAS and at harvest, grain yield, net return and B: C ratio.

PCA was conducted to simplify multivariate data, identifying key drivers (yield, economics and weed density) of treatment differences and visualizing correlations *via.* Bioplot. The principal component analysis show that yield and economic return are the most important factors separating the treatments (explained by PC1), with weed free treatment in $T_{10}$ being the highest performer, followed by $T_8$ and $T_{11}$ (Table 5 and Fig. 1). Biological factors such as monocot and dicot growth stages contribute more modestly to explaining the differences between treatments (reflected in PC2 and Dim2). (Table 5 and Fig. 2) showing dry matter accumulation at harvest, relative growth

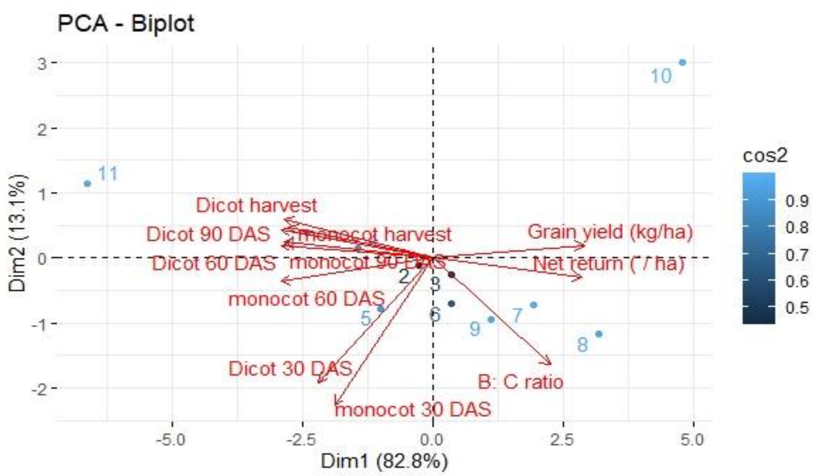


Fig 1. Principal component analysis of weed density, yield and economics at different stages

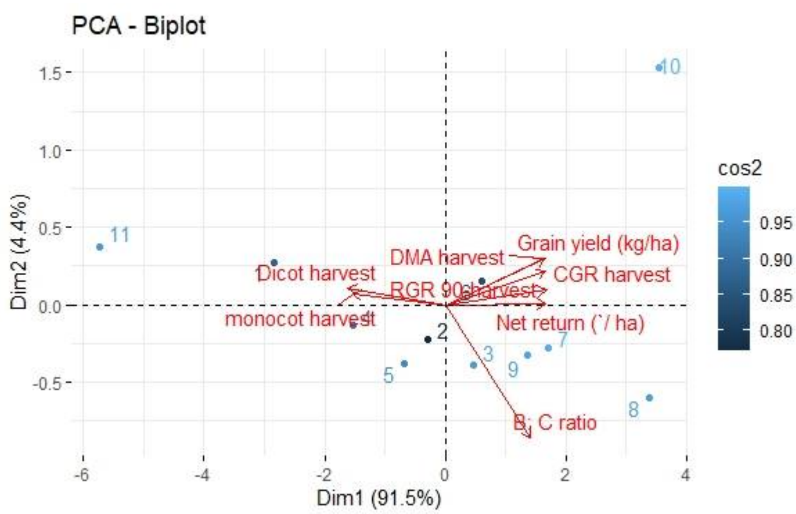


Fig. 2. Principal component analysis of weed density, growth parameters, yield and economics at harvest

rate at 90 DAS- harvest and crop growth rate at harvest which was found positively correlated with grain yield, net return and B:C ratio due to highest acute angle observed in these traits. Treatment $T_{10,}$ $T_8$ and $T_7$ clearly indicated in PCA biplot with PCA value. Monocot and dicot weed at harvest was negatively correlated with grain yield, net return and B:C ratio due to highest obtuse angle and weedy check ($T_{11}$) treatment showed negatively correlation with Sena *et al.* (2002). PCA results confirm that effective weed management, particularly in T8, maximizes grain yield and economic returns by minimizing weed density.

It could be concluded that sequential application of sorghum extract (1:3) + ready-mix of clodinafop + metsulfuron 64 g/ha resulted in significantly reduce weed infestation which create congenial conditions to the crop and increase grain yield (4543 kg/ha) that fetched maximum gross return (Rs. 120351/ha), net return (Rs 87305/ha) and ultimately caused prominent improvement in B: C ratio (3.64) as compare to rest of the treatments. However, it was equally effective as sorghum extract (1:2) + ready-mix of clodinafop + metsulfuron 64 g/ha. The above findings are based on one year experimentation, which needs to be validated through further experimentation to arrive at a recommendation.

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