



Efficacy of Sorghum Extract and Ready-mix Formulation of Clodinafop+Metsulfuron on Growth and Yield of Wheat (*Triticum aestivum* L.)

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ABSTRACT

Background: Sorghum extract + ready-mix clodinafop + metsulfuron herbicide as post-emergence was most effective for broad spectrum weed management in wheat crop. Sorghum extract and herbicide combination increased the growth as well as yield of wheat. Weeds are a major challenge in wheat crop causing poor productivity. At a present time, maximum doses of herbicides are used in wheat crop, but after some time their harmful effect are visible on crop and soil. so sorgoleone allelochemical are used with herbicide. this ecofriendly integrated approach reduce weed density and increase the productivity of wheat.

Methods: The experiment was conducted to work out "Bio-efficacy of sorghum extract and herbicide on growth, yield and quality of wheat (*Triticum aestivum* L.)." The eleven treatment combination sorghum extract alone as well as combined with ready-mix of clodinafop + metsulfuron herbicide with weed free and weedy check was taken during experiment. The experiment was laid out in randomized block design (RBD) during *rabi* season of 2021-22 at Instructional Farm, College of Agriculture, Jodhpur (Rajasthan) India.

Result: Sequential application of sorghum extract (1:3) + ready-mix of clodinafop + metsulfuron 64 g/ha was applied at 21 and 30 DAS, significantly increased plant population, plant height, tillers and SPAD chlorophyll meter reading (SCMR) of wheat. This treatment resulted in significantly higher grain yield 4543 kg/ha and magnitude of increments were 34.87% over weedy check and was comparable with sorghum extract (1:2) + ready-mix of clodinafop + metsulfuron 64 g/ha.

Key words: Clodinafop, Height, Metsulfuron, Population, Sorghum extract, Wheat, Yield.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important crops among the cereals in the India and belongs to family 'Poaceae'. Wheat is a widely grown cereal crop across the world. It offers 20% of the world's resources (Patil *et al.*, 2023). The origin of wheat has been traced to South-West Asia and has a global significance (Kesho *et al.*, 2020). Uttar Pradesh, Madhya Pradesh, Punjab, Haryana, Rajasthan, Maharashtra and Gujarat are major wheat growing states in India. This crop supplies over 20 per cent of the food calories to the world growing population and stands at 2nd place under staple food crops next to rice in India. During (2020) wheat occupied 31.45 million hectare area with a production of 107.59 million tonnes and productivity of 3421 kg/ha (DES, 2020)

Among various food grains, wheat is world-wide in its commercial cultivation on every continent except Antarctica (Singh and Sharma, 2024). wheat and rice are considered as the backbone of the nation's food security. Its grain contains starch (60-90%), protein (11-16.5%), fat (1.5-2%), inorganic ions (1.2-2.0%), vitamins-B complex and vitamin-E (Rueda-Ayala *et al.*, 2011). The wheat grain contains gluten protein that enables leavened dough to rise by forming minute gas cells and this property enables bakers to produce light breads (Jekle and Becker, 2015). Under arid conditions of Western Rajasthan, both monocot and dicot weeds are dominant. Initial 45 days is the period

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considered too critical for weed crop competition in wheat (Yadav *et al.*, 2019). Weed management in wheat is crucial for ensuring optimal crop yield and quality, as weeds compete for essential resources such as water, nutrients and sunlight. Effective weed control helps reduce the risk of diseases and pests, which often thrive in unmanaged

weed populations. Additionally, maintaining a weed-free wheat field enhances harvest efficiency and reduces contamination, leading to better market value and profitability. Eco-friendly weed management is important as it minimizes the environmental impact, preserving soil health and biodiversity while reducing chemical residues in food and water sources. Additionally, sustainable practices help prevent the development of herbicide-resistant weed strains, ensuring long-term agricultural productivity and ecosystem balance. *Chenopodium murale*, *Chenopodium album*, *Asphodelus tenuifolius*, *Melilotus indica*, *Fumaria parviflora*, *Cynodon dactylon*, *Convolvulus arvensis*, *Rumex dentatus* and *Phalaris minor* are the common major weed flora in wheat fields. In Jodhpur region 42.8 per cent of wheat production reduces by only weeds (Singh and Singh, 2004). Therefore, weed density, diversity and community structure of farmland are significantly affected by nature of crops, soil fertility and productivity of crop ecosystem (Ishaq *et al.*, 2017). Weeds, mining more nutrient results in lesser acquisition of nutrient by the crop hence, growth and yield of crop gets affected (Adnan *et al.*, 2020). Mature sorghum plants contain water soluble allelochemicals which are very phytotoxic to certain weeds viz. *Phalaris minor*, *Chenopodium album*, *Rumex dentatus* and *Convolvulus arvensis* (Salawu *et al.*, 2013). Among various allelopathic crops, sorghum is one of the most allelopathic one, that contains allelochemicals like phenolic, alkaloids, flavonoids and terpenoids which suppresses the growth of weeds and increase the production of wheat (Jabran *et al.*, 2015). Foliar application of sorghum water extracts reduced weed density and dry weight by 15 to 17% and 19 to 49%, respectively in sesame crop (Murimwa *et al.*, 2019). However, its allelopathic effect is dependent on dilution of extract. Low concentration of sorghum extract has stimulatory effects on germination and growth of weeds in early stage. Sorghum water extract in different dilution was used by (Cheema *et al.*, 2020) and reported that water extract spray reduced weed biomass by 35 to 40 per cent and increased wheat yield by 10 to 21 per cent. Among phenolic components, benzoic acid, caffeic acid, ferulic acid, gallic acid, syringic acid, coumaric acid and chlorogenic acid are present in sorghum residue (Naboulsi *et al.*, 2018). These allelochemicals have more phytotoxic effects on growth of certain weeds and can reduce weed density and increase growth of wheat (Bhadoria, 2011). Ecofriendly weed management measures are crucial for enhancing the yield of wheat. Integrated approach including non-chemical and chemical weed management practice would be an efficient and economical alternative as well as ecological approach. Therefore, this study was carried out to enumerate the effect of sorghum extract and herbicides on plant population, plant height, number of tillers, SPAD chlorophyll meter reading (SCMR) and yield of wheat.

MATERIALS AND METHODS

The field testing was conducted during *rabi* season of 2021-22 at Instructional Farm, College of Agriculture, Jodhpur (Rajasthan) India, geographically, located between 26°15'N to 26°45' North latitude and 73°00'E to latitude 73°29' East longitude. The study area receives average annual rainfall of 367 mm. and wide deviations in maximum (24.6°C in January to 41.6°C in May) and minimum (9.6 in January to 27.7°C in June) temperature. The soil of the experimental fields was sand-loamy in texture with low in organic carbon and available nitrogen, medium in available phosphorus and high in available potassium.

The experiment comprised eleven treatment combinations, viz, sorghum extract (1:1), Sorghum extract (1:2), Sorghum extract (1:3), Sorghum extract (1:4), Ready mix of clodinafop + metsulfuron 64 g/ha, Sorghum extract (1:1) + ready-mix of clodinafop + metsulfuron 64 g/ha, Sorghum extract (1:2) + ready-mix of clodinafop + metsulfuron 64 g/ha, Sorghum extract (1:3) + ready-mix of clodinafop + metsulfuron 64 g/ha, Sorghum extract (1:4) + ready-mix of clodinafop + metsulfuron 64 g/ha, including two checks (weed free check and weedy check). 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. The dried sorghum plant was cut into 2 to 3 cm pieces with ordinary fodder cutter machine for preparation of fresh extract. Stover of crop was soaked in tape water in ratio of 1:10 weight/volume and kept for 24 hours as such for release of maximum amount of allelochemicals. After 24 hours, extract was filtered with the help of sieve and boiled to reduce the filtrate volume by 95 per cent. According to treatment viz. 1:1, 1:2, 1:3 and 1:4 (sorghum extract/water) dilution sprayed at 21 days after sowing of wheat. Clodinafop + metsulfuron 64 g/ha were applied as post-emergence with the help of knapsack sprayer. Wheat cultivar 'GW 11' was sown by *pura* method at row spacing of 22.5 cm with about 3 to 4 cm in depth using 100 kg seed/ha. The height of five tagged plants was measured in centimeter (cm) from ground level to the longest leaf of the plant at 30, 60, 90 DAS and at harvest stage. The SPAD chlorophyll reading was taken with the help of SPAD chlorophyll meter (SPAD-502) and value was recorded from randomly selected five plants of each plot at different growth stages.

RESULTS AND DISCUSSION

Effect on plant population and plant height

Data showed that significantly higher plant population including tillers (442/m²) was recorded under post-emergence and sequential application of sorghum extract (1:3) + ready-mix of clodinafop + metsulfuron 64 g/ha due to lesser mortality rate during crop season, while application of sorghum extract (1:2) + ready-mix of clodinafop + metsulfuron 64 g/ha recorded next best

treatment which recorded slightly lesser number of plant stand (423/m²) including tillers at final count during experimentation (Table 1).

Post-emergence and sequential application of sorghum extract (1:3) + ready-mix of clodinafop + metsulfuron 64 g/ha in wheat recorded significantly taller plants *i.e.* 51.69, 83.72 and 90.49 cm followed by the treatment sprayed with sorghum extract (1:2) + ready-mix of clodinafop + metsulfuron 64 g/ha, which also recorded next taller plant 47.41, 79.44 and 86.30 cm at 60, 90 DAS and at harvest stage of crop, respectively during experimental year and showed its significant superiority over rest of the treatments except weed free and sorghum extract (1:2) + clodinafop + metsulfuron 64 g/ha at harvest, where these treatments were statistically at par with each other's (Table 2). Sorghum extract and ready-mix herbicide gave higher plant population and

taller plants over weedy check due to reduced weed density which might have resulted in less competition of wheat with weeds for nutrients mainly nitrogen, phosphorus and potash and other resources like space, light and water which are needed in ample quantity for proper growth and development (Rab *et al.*, 2016). Initial plant population and growth attributes at 30 DAS were not affected significantly possibly due to the better competitiveness of the crop against weeds for soil moisture, plant nutrients, solar radiation and space during active growth period. Similar results have been reported by Misbahullah *et al.* (2019) and Kaur *et al.* (2017).

Effect on number of tillers

Application of sorghum extract (1:3) + ready-mix of clodinafop + metsulfuron 64 g/ha significantly produced higher number of tillers (464, 453 and 442/m²) and showed

Table 1: Plant population, grain and straw yield of wheat as influenced by sorghum extract and herbicide.

Treatments	Plant population (per m ²)		Grain yield (kg/ha)	Straw yield (kg/ha)
	Initial	Final (including tillers)		
Sorghum extract (1:1)	193	325	3392	4243
Sorghum extract (1:2)	194	387	3815	4632
Sorghum extract (1:3)	193	393	3933	4754
Sorghum extract (1:4)	195	347	3584	4397
Ready mix of clod. + met. 64 g/ha	196	363	3726	4544
Sorghum extract (1:1) + ready-mix of clod. + met. 64 g/ha	194	398	3999	4823
Sorghum extract (1:2) + ready-mix of clod. + met. 64 g/ha	195	423	4217	4918
Sorghum extract (1:3) + ready-mix of clod. + met. 64 g/ha	193	442	4543	5103
Sorghum extract (1:4) + ready-mix of clod. + met. 64 g/ha	195	415	4116	4913
Weed free	197	461	4850	5265
Weedy check	189	319	2959	4096
SEm±	1.44	3.62	36.42	50.75
CD (P=0.05)	NS	10.68	107.43	149.72

(RM: Ready-mix, clod. + met. - clodinafop + metsulfuron).

Table 2: Plant height of wheat as influenced by sorghum extract and herbicide.

Treatments	Plant height (cm)			
	30 DAS	60 DAS	90 DAS	At harvest
Sorghum extract (1:1)	13.39	39.09	71.10	80.43
Sorghum extract (1:2)	13.46	41.42	73.40	82.89
Sorghum extract (1:3)	13.49	42.64	74.67	83.00
Sorghum extract (1:4)	13.43	39.72	71.76	81.15
Ready mix of clod. + met. 64 g/ha	13.45	40.57	72.56	81.97
Sorghum extract (1:1) + ready-mix of clod. + met. 64 g/ha	13.69	43.13	75.13	83.12
Sorghum extract (1:2) + ready-mix of clod. + met. 64 g/ha	14.01	47.41	79.44	86.30
Sorghum extract (1:3) + ready-mix of clod. + met. 64 g/ha	14.03	51.69	83.72	90.49
Sorghum extract (1:4) + ready-mix of clod. + met. 64 g/ha	13.81	43.33	75.33	83.70
Weed free	14.06	58.13	88.23	94.94
Weedy check	13.36	36.99	68.93	79.07
SEm±	0.19	1.03	1.39	1.68
CD (P=0.05)	NS	3.04	4.10	4.96

(RM: Ready-mix, clod. + met. - clodinafop + metsulfuron).

their superiority over rest of the treatments followed by the treatments sprayed with sorghum extract (1:2) + ready-mix of clodinafop + metsulfuron 64 g/ha was recorded significant number of tillers (447, 437 and 423/m²) at 60, 90 DAS and at harvest stage of crop growth. However, both the treatments showed significant superiority over all treatments except sorghum extract (1:4) + clodinafop + metsulfuron 64 g/ha where Sorghum extract (1:2) + clodinafop + metsulfuron 64 g/ha statistically at par with each other's in producing similar number of tillers counted during field experimentation. Overall, increments in total number of tillers were 29.74, 28.92 and 27.82 per cent higher over weedy check at 60, 90 DAS and at harvest stages of wheat, respectively (Table 3). Treatment sorghum extracts (1:3) also produced significant higher number of tillers (406, 402 and 393/m²) at all growth stage. The increase in the number of tillers in response to the treatments may be due to relatively better weed control

which ultimately facilitated relatively more translocation of photosynthates toward reproductive growth due to lesser crop-weed competition particularly at active growth stage results in more cell division in apical parts of plant that give rise more formation of tillers in wheat. These results also validated the findings of Awan *et al.* (2012).

Effect on chlorophyll content

Sequential application of sorghum extract (1:3) + ready-mix of clodinafop + metsulfuron 64 g/ha significantly increases SPAD chlorophyll meter reading 51.23 and 50.09 and their increment were 25.37 and 26.33 per cent higher over weedy check at 60 and 90 DAS. Sorghum extract (1:2) + ready-mix of clodinafop + metsulfuron 64 g/ha which also outplayed in increasing SPAD chlorophyll meter reading 46.49 and 46.00 at 60 and 90 DAS of wheat, respectively (Table 4). Sorghum extract (1:3) treatment was recorded significantly highest SPAD chlorophyll meter reading 44.06

Table 3: Number of tillers in wheat as influenced by sorghum extract and herbicide.

Treatments	No. of tillers/m ²		
	60 DAS	90 DAS	At harvest
Sorghum extract (1:1)	338	332	325
Sorghum extract (1:2)	396	393	387
Sorghum extract (1:3)	406	402	393
Sorghum extract (1:4)	356	351	347
Ready mix of clod. + met. 64 g/ha	372	367	363
Sorghum extract (1:1) + ready-mix of clod. + met. 64 g/ha	421	417	398
Sorghum extract (1:2) + ready-mix of clod. + met. 64 g/ha	447	437	423
Sorghum extract (1:3) + ready-mix of clod. + met. 64 g/ha	464	453	442
Sorghum extract (1:4) + ready-mix of clod. + met. 64 g/ha	442	433	415
Weed free	484	470	461
Weedy check	326	322	319
SEm±	4.03	3.94	3.62
CD (P= 0.05)	11.90	11.62	10.68

(RM: Ready-mix, clod. + met. - clodinafop + metsulfuron).

Table 4: SPAD chlorophyll meter reading of wheat as influenced by sorghum extract and herbicide.

Treatments	SPAD chlorophyll meter reading		
	30 DAS	60 DAS	90 DAS
Sorghum extract (1:1)	33.72	40.92	38.31
Sorghum extract (1:2)	35.79	43.58	41.19
Sorghum extract (1:3)	36.73	44.06	41.88
Sorghum extract (1:4)	34.75	41.12	39.36
Ready mix of clod. + met. 64 g/ha	35.05	42.08	40.10
Sorghum extract (1:1) + ready-mix of clod. + met. 64 g/ha	37.03	44.63	42.37
Sorghum extract (1:2) + ready-mix of clod. + met. 64 g/ha	38.94	46.49	46.00
Sorghum extract (1:3) + ready-mix of clod. + met. 64 g/ha	39.34	51.23	50.09
Sorghum extract (1:4) + ready-mix of clod. + met. 64 g/ha	37.38	45.69	45.87
Weed free	41.41	56.37	55.47
Weedy check	32.69	38.23	36.90
SEm±	1.77	1.21	1.36
CD (P=0.05)	NS	3.57	4.02

(RM: Ready-mix, clod. + met. - clodinafop + metsulfuron).

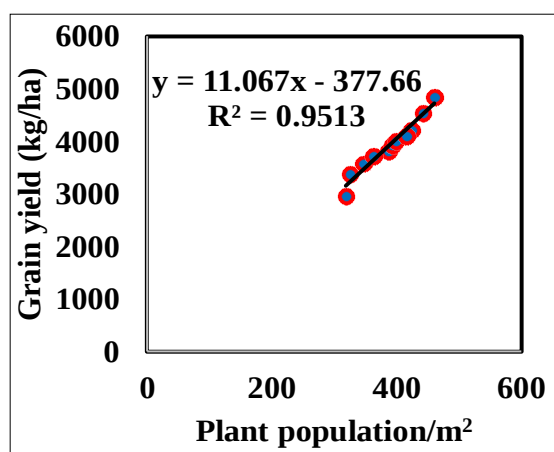


Fig 1: Regression analysis between grain yield and plant population at harvest of wheat.

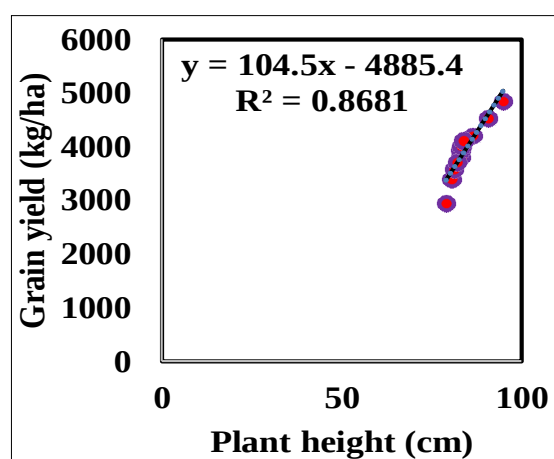


Fig 2: Regression analysis between grain yield and plant height at harvest of wheat.

and 41.88 and showed superiority over weedy check, but statically at par with other diluted sorghum extracts viz. sorghum extract (1:1), sorghum extract (1:2) and sorghum extract (1:4) at 60 and 90 DAS respectively. Sorghum extract and herbicide reduced weed density and increased SPAD chlorophyll meter reading due to better utilization of applied inputs and increase photosynthesis activity in leaves. (Mishra *et al.*, 2021 and Chaudhari *et al.*, 2017).

Effect on yield

Sequential application of sorghum extract (1:3) + ready-mix of clodinafop + metsulfuron 64 g/ha produce significantly higher grain yield 4543 kg/ha and straw yield 5103 kg/ha as compare to other treatments expect to weed free. Sorghum extract (1:2) + ready-mix of clodinafop + metsulfuron 64 g/ha produce 4217 kg grain/ha in wheat, but this treatment was statistically at par with sorghum extract (1:4) + ready-mix of clodinafop + metsulfuron 64 g/ha. Sorghum extract (1:3) treatment significantly harvest grain yield of 3933 kg/ha, while others viz. sorghum extract (1:1), sorghum extract (1:2) and sorghum extract (1:4) also

recorded grain yield of 3392 kg/ha, 3815 kg/ha and 3584 kg/ha (Table 1). Ready-mix application of clodinafop + metsulfuron 64 g/ha resulted in a justifiable grain yield i.e. 3726 kg/ha, which was 20.59 per cent higher over weedy check (Table 1). Suppressive and killing effects on weeds is driven by allelochemicals present in the sorghum extract that might inhibit the physiological process particularly photosynthesis at PS-II in weeds. Naby and Ali (2020); Hamid *et al.* (2017) and Rab *et al.* (2016). Application clodinafop + metsulfuron which kills grassy as well as broad leaved weeds in wheat field, which enable the wheat crop to acquire more nutrients from the soil and same may translocate to the active site where these nutrients accelerate the metabolic function such as cell division and photosynthesis results in more yield. However, efficacy of ready-mix herbicide was tested and found to improve yield of wheat and similar trends were reported by Parita and Rana (2021) and Chaudhary *et al.* (2021).

Regression studies

It was noticed that grain yield of wheat positively correlated with plant population with a correlation co-efficient of 0.9513. This was further supported by the regression analysis; the grain yield of wheat was increase by 11.067 kg/ha (Fig 1). The grain yield and plant height at harvest stage were positively correlated with correlation co-efficient of 0.8681. This was further proved by regression analysis; the grain yield of wheat was increased by 104.5 kg/ha (Fig 2).

CONCLUSION

It could be concluded that sequential application of sorghum extract (1:3) + ready-mix of clodinafop + metsulfuron 64 g/ha resulted in significantly higher plant population, plant height, tillers, chlorophyll content, grain and straw yield of wheat. 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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Conflict of interest

Authors have declared no conflict of interests exist.

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