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Response of sulphur and weed management practices on cowpea [*Vigna unguiculata* L.]

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Abstract
A field experiment entitled "Response of Sulphur and Weed Management Practices on Cowpea [*Vigna unguiculata* L.]" was conducted on loamy sand soil at research farm, School of Agricultural Science, Suresh Gyan Vihar University, Jaipur, Rajasthan during *Kharif* 2023 seasons. The field experiment design was randomised block design with ten treatments. Cowpea variety RC-101 was sown row spacing 30 cm and seed rate 40 kg ha^{-1}. Maximum accumulation of dry matter per plant of cowpea in application of sulphur (30 kg ha^{-1}) + hand weeding twice (20 and 40 DAS) (16.17 g plant^{-1}) and followed by sulphur (2030 kg ha^{-1}) + hand weeding twice (20 and 40 DAS) (15.68 g plant^{-1}), sulphur (30 kg ha^{-1}) + pendimethalin (0.75 ml ha^{-1}) pre-emergence (15.05 g plant^{-1}). The increase seed yield due to sulphur (30 kg ha^{-1}) + hand weeding twice (20 and 40 DAS), sulphur (20 kg ha^{-1}) + hand weeding twice (20 and 40 DAS), sulphur (30 kg ha^{-1}) + pendimethalin (0.75 ml ha^{-1}) pre-emergence, sulphur (10 kg ha^{-1}) + hand weeding twice (20 and 40 DAS) in the tune of 53.72, 45.67, 44.72 and 39.44 percent respectively, over to control. Maximum net return and B: C were recorded with application of sulphur (30 kg ha^{-1}) + pendimethalin (0.75 ml ha^{-1}) pre-emergence (Rs 32130 ha^{-1}) and (2.03).

Keywords: Dry matter accumulation, Pod, seed and net return

Introduction
Cowpea (*Vigna unguiculata* L.), commonly referred to as "Lobia," serves multiple purposes as a pulse, fodder, and green manure crop. It holds a significant historical presence in the Asian and African tropics as one of the oldest pulse crops. Known for its high protein content and diverse nutrients, cowpea is often likened to vegetable meat. Pulses are crucial in the Indian diet, providing essential vegetable protein that complements the cereal-based staple. In India, pulses are cultivated on approximately 28.34 million hectares, yielding 23.15 million metric tons annually, with an average productivity of 817 kg ha^{-1}. In Rajasthan, cow pea is cultivated on 0.85-million-hectare, production 0.44 million ton with productivity of 509 kg ha^{-1} (GOI 2021-22). Sulphur is a key component of cysteine, amino acids like methionine, and chlorophyll (Wani *et al.*, 2001) [15]. It plays a crucial role in chlorophyll formation, enzyme activation, and enhancing crop yields. Functionally, sulfur significantly impacts crop yield and quality, enhancing aroma and flavor while imparting cold resistance, earning it recognition as a "quality nutrient." However, sulfur deficiency can reduce both yield and quality, particularly in soils lacking sufficient sulfur. Such deficiencies are widespread globally, often manifesting early in crop growth stages due to sulfur's susceptibility to leaching from the soil surface. Among various components of production technology, weed control in cowpea needs due attention. As this crop is grown in poor soils with poor management practices, weed infestation is one of the major causes of low productivity (Singh 1992) [14]. Pre-emergence herbicides like pendimethalin effectively control the grassy and broad-leaf weeds during early phase of crop growth. Post-emergence (PoE) application of imazethapyr has also been reported to provide effective weed control (Singh *et al.* 2014 and Singh *et al.* 2017) [8, 13]. Combinations of PE and PoE herbicides or certain ready-mix formulations are commercially available which may be helpful to manage complex weed flora and reduce crop-weed competition. Pendimethalin controls initial flush of annual grasses and some of the broadleaf weeds (Khaliq *et al*. 2002 and Singh 2011) [3, 9].

Pendimethalin inhibits cell division and cell elongation in susceptible plants. Therefore, Pendimethalin along with a manual weeding at 25-30 days after sowing (DAS) are usually recommended (Khaliq *et al.* 2002 and Akter *et al.* 2013) [3, 1].

Materials and Methods

A field School of Agriculture, Suresh Gyan Vihar University, Jaipur located at 26.81°N latitude and 75.86°E longitude with an altitude of 435 m above mean sea level in the western dry region of India. The soil was sandy loam in texture, neutral in soil reaction, low in organic carbon and available nitrogen, and medium in available phosphorus and potassium**.** The experiment comprised ten treatment combinations that were laid out in randomized block design and replicated three times. The treatments were randomly allocated to different plots using random number table of Fisher and Yates (1965). The recommended dose of fertilizers was 60 kg N, 30 kg P_2O_5 were applied to all the treatments. Entire dose of nitrogen, phosphorus was applied as basal at the time of sowing. sulphur was applied to all of the plots as per the treatments through soil application. The seeds were sown on 14.07.2023. Inter-row distance of 30 cm row to row and 10 cm plant to plant were maintained in control plots only and furrows were opened at a depth of 5-6 cm. Weed control practices were implemented according to the specified treatment protocols. This ensured that effective methods were used to manage weeds in the experimental setup.

Results and Discussion

Maximum plant height and dry matter accumulation were recorded with sulphur (30 kg ha^{-1}) + hand weeding twice (20 and 40 DAS) which was significantly superior to control, sulphur (10 kg ha^{-1}) + Pendimethalin (0.75 ml ha^{-1}) pre-emergence, sulphur (10 kg ha^{-1}) + Imazethapyr (75 g ha^{-1}) post-emergence, sulphur (20 kg ha^{-1}) + pendimethalin (0.75 ml ha^{-1}) pre-emergence, sulphur (20 kg ha^{-1}) + Imazethapyr (75 g ha^{-1}) post-emergence and sulphur (30 kg ha^{-1}) + Imazethapyr (75 g ha^{-1}) post-emergence and remained statistically at par with sulphur (10 kg ha^{-1}) + hand weeding twice (20 and 40 DAS), sulphur (20 kg ha^{-1}) + hand weeding twice (20 and 40 DAS), sulphur (30 kg ha^{-1}) + hand weeding twice (20 and 40 DAS) and sulphur (30 kg ha^{-1}) + pendimethalin (0.75 ml ha^{-1}) pre-emergence at 30 DAS and harvest stage. Its might be due to lower weed infestation for longer period of time and lesser nutrient removal by weeds. Kumar *et al*. (2016) [4] also reported similar results.

Number of pods $plant^{-1}$ and seed pod^{-1} were significantly influenced by different sulphur level and weed management treatments and maximum number of pods per plant were recorded with application of sulphur (30 kg ha^{-1}) + hand weeding twice (20 and 40 DAS) followed by sulphur (30 kg ha^{-1}) + pendimethalin (0.75 ml ha^{-1}) pre-emergence, sulphur (20 kg ha^{-1}) + hand weeding twice (20 and 40 DAS) and sulphur (10 kg ha^{-1}) + hand weeding twice (20 and 40 DAS). Hand weeding increased the pods $plant^{-1}$ and seed pod^{-1} might be due to better growth and partitioning of photosynthates under poor weed dry weight and density. Pendimethalin (0.75 ml ha^{-1}) pre-emergence also significantly increased the pods $plant^{-1}$ and seed pod^{-1} might be due to better growth and development of crop. Similar finding also reported by Sahu *et al*. (2023) [12].

The increase seed yield due to sulphur (30 kg ha^{-1}) + hand weeding twice (20 and 40 DAS), sulphur (20 kg ha^{-1}) + hand weeding twice (20 and 40 DAS), sulphur (30 kg ha^{-1}) + pendimethalin (0.75 ml ha^{-1}) pre-emergence, sulphur (10 kg ha^{-1}) + hand weeding twice (20 and 40 DAS) in the tune of 53.72, 45.67, 44.72 and 39.44 percent respectively, over to control. The increase the stover yield of sulphur (30 kg ha^{-1}) + hand weeding twice (20 and 40 DAS), sulphur (30 kg ha^{-1}) + pendimethalin (0.75 ml ha^{-1}) pre-emergence, sulphur (20 kg ha^{-1}) + hand weeding twice (20 and 40 DAS), sulphur (20 kg ha^{-1}) + pendimethalin (0.75 ml ha^{-1}) pre-emergence and sulphur (30 kg ha^{-1}) + Imazethapyr (75 g ha^{-1}) post-emergence in the tune of 52.71, 43.54, 39.02, 38.48 and 34.05 percent, respectively over to control. The yield increase was mainly due to increased number of pods per plant and seed per pod which was directly correlated to the yield of cow pea. Kumar *et al*., 2016 [4] reported found similar finding. This data was in conformity with the finding of Lakra, D. S. (2017) [11], Rao *et al*. (2011) [5] and Chaudhari *et al*. (2016) [7]. Application of sulphur levels with herbicides significantly influenced the yield attributes and yields of chick pea. Its might be due to the fact that sulphur levels give an important role to change and improve the physico chemical properties of soil, improve the growth and development of the crop, thus better availability of nutrients to the crop thus higher translocation toward reproductive structure and also higher photosynthesis activity might have resulted in significant enhanced in yield and yield attributes. In agreement with observation, Dhaker *et al*. 2010 [10] and Maity and Giri 2003 [17].

Maximum net return and B:C were recorded with application of sulphur (30 kg ha^{-1}) + pendimethalin (0.75 ml ha^{-1}) pre-emergence (Rs 32130 ha^{-1}) and (2.03). The increased seed yield observed with this treatment likely contributed to higher net returns. These results align closely with those reported by Yadav *et al*. (2014). Therefore, based on the above findings, it can be concluded that hand weeding twice, at 20 and 40 days after sowing (DAS), is recommended for effective control of mixed weed flora, leading to increased productivity and profitability.

Table 1: Response of Sulphur and Weed Management Practices on growth and yield attributes

Treatments	Plant height (cm)		Dry matter accumulation (g)		Number of pods $plant^{-1}$	Number of seed pod^{-1}
	At 30 DAS	At harvest	At 30 DAS	At harvest		
Control	14.83	51.67	3.43	10.03	14.22	7.22
Sulphur (10 kg ha^{-1}) + Hand weeding twice (20 and 40 DAS)	20.40	67.07	5.13	15.03	18.33	11.33
Sulphur (10 kg ha^{-1}) + Pendimethalin (0.75 ml ha^{-1}) PE	16.77	57.05	3.67	14.06	17.41	10.41
Sulphur (10 kg ha^{-1}) + Imazethapyr (75 g ha^{-1}) PoE	16.33	55.67	3.57	13.97	16.33	9.33
Sulphur (20 kg ha^{-1}) + Hand weeding twice (20 and 40 DAS)	21.07	68.83	5.47	15.68	19.00	12.00
Sulphur (20 kg ha^{-1}) + Pendimethalin (0.75 ml ha^{-1}) PE	18.00	58.17	4.18	14.53	18.41	11.41
Sulphur (20 kg ha^{-1}) + Imazethapyr (75 g ha^{-1}) PoE	17.67	57.38	3.82	14.24	17.55	10.55
Sulphur (30 kg ha^{-1}) + Hand weeding twice (20 and 40 DAS)	22.07	69.80	5.73	16.17	19.89	12.89
Sulphur (30 kg ha^{-1}) + Pendimethalin (0.75ml ha^{-1}) PE	19.40	59.30	4.60	15.05	19.04	12.04
Sulphur (30 kg ha^{-1}) + Imazethapyr (75 g ha^{-1}) PoE	18.37	58.52	4.37	14.68	18.11	11.11
SEm+/-	1.14	2.93	0.29	0.64	0.87	0.87
CD=0.05%	3.40	8.70	0.86	1.90	2.57	2.57

Table 2: Response of Sulphur and Weed Management Practices on yield and economics

Treatments	Seed yield (Kg ha^{-1})	Straw yield (Kg ha^{-1})	Bioloigcal yield (Kg ha^{-1})	Net return	B:C ratio
Control	600	952	1552	15715	1.56
Sulphur (10 kg ha^{-1}) + Hand weeding twice (20 and 40 DAS)	837	1296	2133	23368	1.62
Sulphur (10 kg ha^{-1}) + Pendimethalin (0.75 ml ha^{-1}) PE	790	1204	1994	27624	1.93
Sulphur (10 kg ha^{-1}) + Imazethapyr (75 g ha^{-1}) PoE	773	1189	1962	26415	1.89
Sulphur (20 kg ha^{-1}) + Hand weeding twice (20 and 40 DAS)	874	1324	2198	25233	1.66
Sulphur (20 kg ha^{-1}) + Pendimethalin (0.75 ml ha^{-1}) PE	813	1318	2132	29014	1.95
Sulphur (20 kg ha^{-1}) + Imazethapyr (75 g ha^{-1}) PoE	793	1246	2040	27304	1.90
Sulphur (30 kg ha^{-1}) + Hand weeding twice (20 and 40 DAS)	922	1454	2376	28326	1.73
Sulphur (30 kg ha^{-1}) + Pendimethalin (0.75ml ha^{-1}) PE	868	1367	2235	32130	2.03
Sulphur (30 kg ha^{-1}) + Imazethapyr (75 g ha^{-1}) PoE	826	1276	2103	28898	1.93
SEm+/-	62	85	146	3832	0.12
CD=0.05%	185	253	434	11385	0.34

Conclusion

The field experiment conducted on the response of sulfur and weed management practices on cowpea (*Vigna unguiculata* L.) revealed significant findings regarding plant growth, yield attributes, and economic returns. The application of sulfur at a rate of 30 kg ha^{-1} combined with manual weeding twice (at 20 and 40 days after sowing) resulted in the highest dry matter accumulation (16.17 g plant^{-1}) and seed yield (922 kg ha^{-1}), showcasing the effectiveness of this treatment in enhancing crop performance. Furthermore, the incorporation of pendimethalin as a pre-emergence herbicide also contributed positively to yield and economic viability, with a maximum net return of Rs 32,130 ha^{-1} and a benefit-cost ratio of 2.03.

These results indicate that effective weed management, particularly through hand weeding and the strategic use of herbicides alongside sulfur application, can significantly improve cowpea productivity and profitability in loamy sand soils. Given the critical role of sulfur in enhancing crop growth and yield, its integration into management practices for cowpea cultivation is recommended. This study underscores the importance of combining nutritional management with effective weed control to achieve sustainable agricultural practices and improved yields in pulse crops like cowpea.

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