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Yield and Growth Attributes of Chia (*Salvia hispanica* L.) as Influenced by Weed Management Practices

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Abstract: Among all agronomical practices of crop cultivation, weed management is a necessary practice for any crop specially the chia being a newly introduced crop, it becomes necessary to study weed dynamics in the crop and find suitable weed management practice to obtain high seed yield and quality of the chia seed. A field experiment was conducted at research farm of Agricultural Research Station, Mandor, Agriculture University, Jodhpur during *Rabi* season of 2021-22 to find out efficacy of different herbicides on chia (*Salvia hispanica* L.) under western Rajasthan. The treatments comprised of herbicides namely bentazon 48% SL 500 g ha^{-1} and 750 g ha^{-1} (30 DAS as post emergence (PoE), fluazifop-p-butyl 11.1% SL 100 g ha^{-1} and 200 g ha^{-1} (30 DAS PoE), sulfentrazone 39.6% SC 50 g ha^{-1} and 75 g ha^{-1} as pre emergence (PE), pendimethalin 38.7% CS 200 g ha^{-1} and 400 g ha^{-1} (PE), weed free and weedy check were laid out in randomized block design with three replications. It was found that application of bentazon 48% SL 750 g ha^{-1} recorded significantly higher plant height (75.18 cm), total no. of branches $plant^{-1}$ (18.16) and dry matter accumulation (82.23 g m^{-2}), seed yield (495 kg ha^{-1}), straw yield (197 kg ha^{-1}), biomass yield (755 kg ha^{-1}) and harvest index (65.56). Among pre-emergence herbicides, sulfentrazone 39.6% SC 75 g ha^{-1} and pendimethalin 38.7% CS 400 g ha^{-1} were found statistically equally effective in controlling weeds in chia.

Key words: Chia, dry matter, herbicide, number of branches, plant population, yield.

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Chia (*Salvia hispanica* L.) is a medicinal and dietary plant species belongs to *Lamiaceae* family native from Mexico and Guatemala (Ixtaina *et al*., 2008). It is mainly cultivated in central Mexico, Guatemala, Australia, south America and Argentina. The cultivation of chia in India has been initiated in small pockets in Madhya Pradesh, Andhra Pradesh, Gujarat, Maharashtra, Karnataka, Rajasthan, Haryana and Himachal Pradesh. Due to increasing awareness for health and nutritional value of food for human diet especially after COVID era, the popularity of chia crop has also increased in Rajasthan state

and recently it has been included in package of practices of Zone Ia of Rajasthan. In Rajasthan, it is grown in some areas of Jalore, Jodhpur, Chittorgarh and Bhilwara districts.

The weed control becomes necessary and important; due to the high pressure that occur at the initial stage of the crop development which can severely affect the yield and quality of the final product of crop (Karkanis *et al*., 2018). The critical period of crop weed competition in chia crop extends up to 45 days after emergence. Therefore, it becomes relevant to control the weeds infestation in field at the beginning stage of the crop cycle. The hand hoeing is still the main weed control practice. However, it is not practicable due to limited availability of labour and it's higher cost. The destruction of seed bank of weed flora through use of herbicides at pre-emergence stage would be beneficial practice. Chia being a newly introduced crop, it becomes necessary to study the suitable weed management practice to obtain high seed yield and quality of the chia seed.

Material and Methods

The field experiment was conducted at Research Farm of ARS, Mandor, Agriculture University, Jodhpur during *Rabi* season of 2021-22. (26°15′ N to 26°45′ North latitude and 73°00′ E to 73°29′ East longitude) The soil of the experimental field was sandy loam in texture, slightly alkaline in reaction (pH 8.2), low in organic carbon (0.13%) and available nitrogen (176 kg ha^{-1}), whereas medium in phosphorus (23.1 kg P_2O_5 ha^{-1}) and available potassium (330 kg K_2O ha^{-1}). There were ten treatments consisting of different weed management practices viz. bentazon 48% SL 500 g ha^{-1} at 30 DAS (T_1), bentazon 48% SL 750 g ha^{-1} at 30 DAS (T_2), fluazifop–p- butyl 11.1% SL 100 g ha^{-1} at 30 DAS (T_3), fluazifop–p-butyl 11.1% SL 200 g ha^{-1} at 30 DAS (T_4), sulfentrazon 39.6% SC 50 g ha^{-1} as pre-emergence (T_5), sulfentrazon 39.6% SC 75 g ha^{-1} as pre-emergence (T_6), pendimethalin 38.7% CS 200 g ha^{-1} pre-emergence (T_7), pendimethalin 38.7% CS 400 g ha^{-1} pre-emergence (T_8), weed free (T_9) and weedy check (T_{10}). The experiment was laid out in 4.0 m × 3.0 m plot size of randomized block design with three replications. During the experiment, the observations on plant population (initial and final), plant height (30, 60, 90 DAS and at harvest), no. of branches per plant (primary and total), Dry matter accumulation (60, 90 DAS and at harvest) and yield of chia crop were recorded.

Result and Discussion

Plant population

The data (Table 1) pertaining to plant population per ha of chia at harvest indicated that plant population was not influenced significantly due to various weed control measures.

Plant height

Plant height was significantly influenced by all the herbicides treatments i.e. pre-emergence or post-emergence at all the growth stages of chia except 30 DAS (Table 1). The maximum plant height was recorded by weed free treatment at 60, 90 DAS and at harvest stage. Application of bentazon 48% SL 750 g ha^{-1} was next superior treatment which was followed by application of bentazon 48% SL 500 g ha^{-1}. Sulfentrazon 39.6% SC 75 g ha^{-1} and pendimethalin 38.7% CS 400 g ha^{-1} as pre-emergence were the next treatments in order of their effectiveness in enhancing the plant height at all stages of the crop.

Number of branches at harvest

All the treatments significantly increased the number of branches per plant than unweeded control (Table 1). Among post- emergence herbicides, bentazon 48% SL 750 g ha^{-1} recorded maximum number of primary and total branches of chia which was closely followed by application of bentazon 48% SL 500 g ha^{-1}. These treatments registered 42.4 and 42.2% higher total branches per plant than weedy check, respectively. Among pre-emergence herbicides, sulfentrazon 39.6% SC 50 g ha^{-1}, sulfentrazon 39.6% SC 75 g ha^{-1}, pendimethalin 38.7% CS 200 g ha^{-1} and pendimethalin 38.7% CS 400 g ha^{-1} recorded 36.6, 38.1, 33.2 and 37.6% higher total branches than weedy check. Both the doses of post-emergence application of fluazifop–p-butyl 11.1% SL i.e. 100 and 200 g ha^{-1} also enhanced the number of total branches per plant to the extent of 13.2 and 22 in comparison to weedy check treatment, respectively. The maximum increase in total branches of chia (45.3 %) was recorded by weed free over weedy check.

Table 1. Effect of herbicides on Plant Population, plant height, Number of Branches and Dry Matter Accumulation of chia

Treatments	Plant population (No. ha^{-1})		Plant height (cm)				Number of branches plants^{-1}		Dry matter accumulation (g m^{-2})		
	Initial	Final	At 30 DAS	At 60 DAS	At 90 DAS	At harvest	Primary	Total	At 60 DAS	At 90 DAS	At harvest
T1	333056	310110	5.53	26.68	74.31	74.91	6.75	18.02	17.91	44.83	80.11
T_2	333088	310998	5.53	27.97	74.89	75.18	6.82	18.16	19.22	45.91	82.23
T_3	331795	307814	5.52	22.99	66.29	66.46	5.43	14.34	15.44	39.93	65.71
T_4	332129	308487	5.50	23.09	66.70	67.25	5.52	15.46	15.33	41.25	70.65
T_5	332010	309240	5.58	23.16	66.78	66.84	6.35	17.30	15.78	41.13	72.65
T_6	331372	308612	5.66	23.36	66.92	66.96	6.46	17.50	16.41	43.27	77.30
T_7	332471	309588	5.55	23.62	65.37	65.56	5.92	16.87	15.75	40.89	66.96
T_8	331527	308721	5.64	23.22	66.88	67.00	6.42	17.43	16.37	42.27	73.41
T_9 Weed free	333056	314444	5.69	28.23	74.98	75.35	6.86	18.41	20.23	50.16	88.14
T_{10} Weedy check	328835	297599	5.49	20.65	61.21	61.78	5.29	12.67	14.06	30.52	52.36
SEm±	1785	9566	0.31	01.23	02.67	02.67	0.31	00.78	00.75	02.03	03.68
CD (*P = 0.05*)	NS	NS	NS	03.64	07.95	07.93	0.92	02.32	02.23	06.02	10.93

T1-Bentazon 48% SL 500 g ha^{-1} at 30 DAS, T_2-Bentazon 48% SL 750 g ha^{-1} at 30 DAS, T_3- Fluazifop –p-butyl 11.1% SL100 g ha^{-1} at 30 DAS, T_4- Fluazifop –p-butyl 11.1% SL 200 g ha^{-1} at 30 DAS, T_5- Sulfentrazon 39.6% SC 50 g ha^{-1} as (PE), T_6- Sulfentrazon 39.6% SC 75 g ha^{-1} as (PE), T_7- Pendimethalin 38.7% CS 200 g ha^{-1} as (PE), T_8- Pendimethalin 38.7% CS 400 g ha^{-1} as (PE), T_9- Weed free, T_{10} - Weedy check

Dry matter accumulation

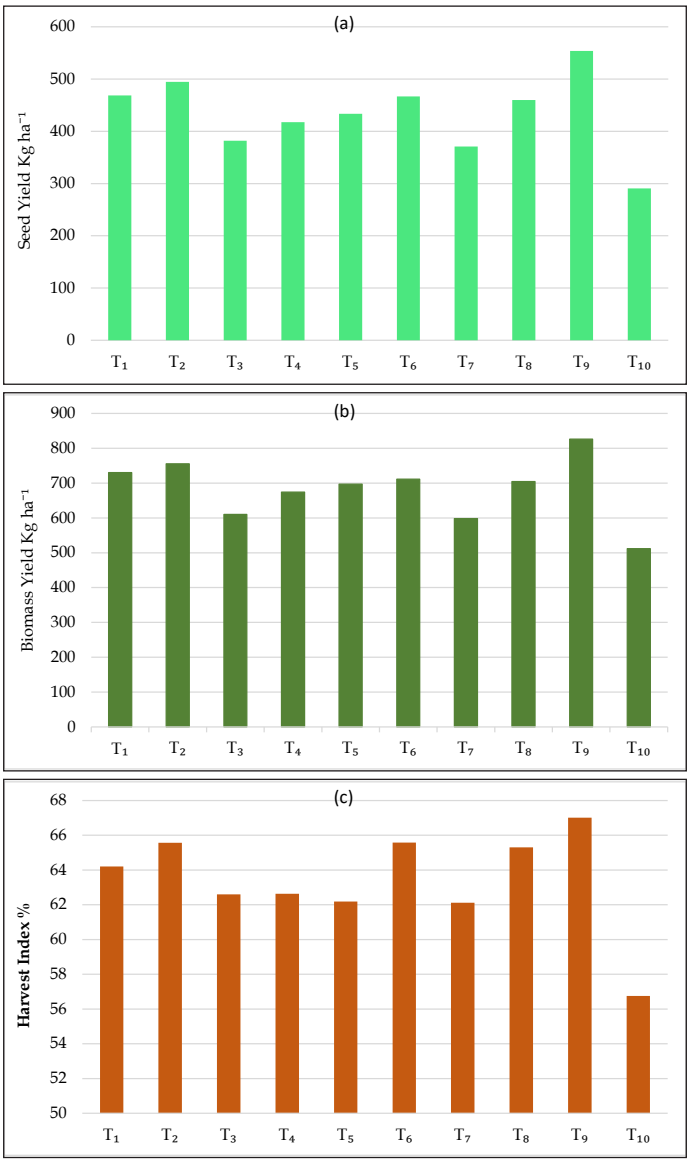
All the weed control treatments produced significantly higher crop dry matter than weedy check at all the stages except 60 DAS. At 60 DAS stage, post-emergence application of fluazifop–p-butyl 11.1% SL 100 and 200 g ha^{-1} and pre-emergence application of sulfentrazon 39.6% SC 50 g ha^{-1} and pendimethalin 38.7% CS 200 g ha^{-1} exhibited statistically similar crop dry matter accumulation than unweeded control. Significantly higher dry matter accumulation was recorded by post-emergence application of bentazon 48% SL applied 750 g ha^{-1} and 500 g ha^{-1} which increased the dry matter by 36.7 and 27.4%, respectively at 60 DAS, 50.4 and 46.9% at 90 DAS and 57.0 and 53% at harvest, respectively. Pre-emergence herbicide sulfentrazon 39.6% SC 75 g ha^{-1} and pendimethalin 38.7% CS 400 g ha^{-1} recorded higher dry matter over weedy check by 41.8 and 38.5%, respectively at 90 DAS and 47.6 and 40.2%, respectively at harvest. The maximum increase in dry matter of chia over weedy check was 43.9, 64.3 and 68.3% at 60, 90 and at harvest, respectively due to weed free treatment.

Results revealed that different weed control treatments differed significantly in their effect on plant height, number of primary and total branches and dry matter accumulation of chia. All the treatments significantly enhanced these growth characters of chia as compared to weedy check. Post-emergence application of bentazon 48% SL 750 g ha^{-1} recorded maximum plant height, number of primary and total branches and dry matter accumulation of chia over weedy check.

The improvement in growth characters of chia due to weed control treatments in present investigation could mainly be ascribed to the reduced density and dry weight of weeds. It resulted least competition for growth inputs *viz*., space, moisture, nutrients, light etc. The weed free environment provided by these treatments reduced the crop-weed competition to the extent of their efficacy in weed control which led to better growth of crop in terms of plant height, branching and dry matter accumulation. Weed free environment also saved nutrients, moisture, sunlight and space that would have otherwise been utilized by freely growing weeds under infested conditions. Contrary to this, uncontrolled weed growth throughout the crop season in weedy check plots arrested the crop growth due to severe crop-weed competition. Similar findings were also obtained by Maciel *et al.* (2019), Yadav *et al.* (2019) and Singh *et al*. (2020).

Yield

It is apparent from the data on yield (seed and biomass yield kg ha^{-1}) of chia (Fig.1 a and b). that different weed control treatments had significant influence on yield/ ha of chia. The yield/ha of chia was found statistically significant among all the herbicides treatments (pre-emergence or post-emergence) as compared to weedy check. Application of post-emergence herbicides resulted in more yield of chia than application of pre-emergence herbicides and weedy check. Among post-emergence herbicides, bentazon 48% SL 750 g ha^{-1} recorded significantly higher yield ha^{-1} followed by application of bentazon 48% SL 500 g ha^{-1}, sulfentrazon 39.6% SC 75 g ha^{-1} and pendimethalin 38.7% CS 400 g ha^{-1}. These treatments were statistically at par to each other and significantly superior over fluazifop–p-butyl 11.1% SL 100 g ha^{-1}, fluazifop–p-butyl 11.1% SL 200 g ha^{-1}, pendimethalin 38.7% CS 200 g ha^{-1} and weedy check. The maximum reduction in yield as compared to weed free was due to weedy check followed by pendimethalin 38.7%



T_1-Bentazon 48% SL 500 g ha^{-1} at 30 DAS, T_2-Bentazon 48% SL 750 g ha^{-1} at 30 DAS, T_3- Fluazifop –p-butyl 11.1% SL100 g ha^{-1} at 30 DAS, T_4- Fluazifop –p-butyl 11.1% SL 200 g ha^{-1} at 30 DAS, T_5- Sulfentrazon 39.6% SC 50 g ha^{-1} as (PE), T_6- Sulfentrazon 39.6% SC 75 g ha^{-1} as (PE), T_7- Pendimethalin 38.7% CS 200 g ha^{-1} as (PE), T_8- Pendimethalin 38.7% CS 400 g ha^{-1} as (PE), T_9- Weed free, T_{10}- Weedy check

Fig. 1. Effect of herbicides on (a). seed yield kg ha^{-1}, (b) biomass yield kg ha^{-1} and (c) harvest index (%) of chia

CS 200 g ha^{-1}, fluazifop–p-butyl 11.1% SL 100 g ha^{-1}, fluazifop–p-butyl 11.1% SL 200 g ha^{-1} and sulfentrazon 39.6% SC 50 g ha^{-1}.

The higher values of yield attributes coupled with the higher crop dry matter recorded under these treatments might be the most probable reason of higher yield. Furthermore, higher yields were attributed due to increase in growth and yield parameters thus favored accumulation of more sink which ultimately increased the yield. Results obtained in present investigation are strongly supported with the finding of Mukherjee (2014), Walsh *et al.* (2015), Tomar (2015), Gupta and Kushwah (2016) and Maciel *et al.* (2018).

Harvest index (%)

The data (Fig. c). pertaining to harvest index of chia indicated that harvest index of chia did not influence significantly due to various weed control measures. A numerically higher value of harvest index was recorded due to higher dose of herbicides and weed free treatments.

Conclusion

The significantly higher growth attributes and yield of chia was recorded with the application of bentazon 48% SL 750 g ha^{-1}. Sulfentrazon 39.6% SC 75 g ha^{-1} and pendimethalin 38.7% CS 400 g ha^{-1} as pre-emergence were found next superior treatments which efficiently controlled the weeds and produced higher yield of chia.

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