Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

J P P Journal of Pharmacognosy and Phytochemistry

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2017; 6(3): 06-08
Received: 02-03-2017
Accepted: 03-04-2017

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Weed management and sulphur nutrition in clusterbean for higher productivity and profitability

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Abstract
An experiment was conducted during *kharif* seasons of 2013 and 2014 at Instructional Farm of Rajasthan college of Agriculture, Udaipur (Rajasthan) to evaluate the effect of weed management and sulphur nutrition on weed density, their biomass, productivity of Clusterbean [*Cyamopsis tetragonoloba* (L.) Taub] and profitability in terms of net returns and BC ratio. Hand weeding twice at 20 and 40 DAS recorded minimum weed count and weed dry matter at 50 DAS. m The minimum weed dry matter of narrow-leaved (129 kg ha^{-1}), broad-leaved (106 kg ha^{-1}) and total weed dry weight (235 kg ha^{-1}) was recorded under two hand weeding treatment which was closely followed by sequential application of pre emergence application of pendimethalin 0.75 kg ha^{-1}followed by post emergence application of imazethapyr 0.075 kg ha^{-1}. The highest yield attributing characters *viz.*, cluster $plant^{-1}$, pods $cluster^{-1}$, seeds $pods^{-1}$, 1000 seed weight and seed yield $plant^{-1}$ were recorded under two hand weeding followed by sequential application of pendimethalin with imazethapyr. The highest seed (1218 kg ha^{-1}) and haulm (2440 kg ha^{-1}) was registered in hand weeded twice treatment while net returns of ₹ 36952 and BC ratio of 2.60 was recorded pendimethalin fb imazethapyr.

Keywords: Clusterbean, imazethapyr, pendimethalin, weed management, sulphur, yield

Introduction
Clusterbean is a *kharif* legume grown for feed, fodder, guar gum and vegetable purpose. Among leguminous crops it is comparatively more drought hardy which is grown during rainy season in arid and semi arid regions of India. Rajasthan is the largest producer followed by Haryana in India. There is an acute crop-weed competition during early crop growth stage due to slow initial crop growth and weeds grow at faster pace. Weeds infects vigorously due to frequent rains and presence of weeds beyond critical period of crop weed competition results in yield reduction to the tune of 45.46 per cent (Sangwan *et al*., 2016) [4]. Therefore, weed control needs to be restored to exploit the yield potential of this crop. Besides application of N and P in legumes sulphur is now required as fourth major plant nutrient (Tandon and Messick, 2007). Results of research over the years have convincingly shown that S application can bring about significant increases in crop yield, produce quality and farmers income.

Material and Methods
Field experiment was conducted during *kharif* seasons of 2013 and 2014 at Instructional Farm of Rajasthan college of Agriculture, MPUAT Udaipur. The soil was medium in available nitrogen (274.56 and 279.61 kg ha^{-1}) and phosphorus (19.27 and 18.69 kg ha^{-1}) and high in available potassium (318.83 and 324.17 kg ha^{-1}), low in sulphur (9.7 and 9.6 ppm) during 2013 and 2014, respectively. The experiment consisted of eight weed management treatments *viz.* weedy check, one hand weeding at 20 DAS, two hand weeding at 20 and 40 DAS, pre-emergence application of pendimethalin 1.0 kg ha^{-1}, post-emergence application of imazethapyr 0.1 kg ha^{-1}, post-emergence application of quizalofop-ethyl 0.05 kg ha^{-1}, pre-emergence application of pendimethalin 0.75 kg ha^{-1} fb post-emergence imazethapyr 0.075 kg ha^{-1} and pre-emergence pendimethalin 0.75 kg ha^{-1} fb post-emergence quizalofop-ethyl 0.04 kg ha^{-1}. All herbicides were applied with knap-sack sprayer fitted with flat fan nozzle with discharge rate of 600 liter water/ha. Four levels of sulphur (control, 15, 30 and 45 kg ha^{-1}) supplied through mineral gypsum, thereby making 32 treatments combinations. The experiment constituted in split plot design with weed management treatments assigned in main plots and sulphur in sub plots. All treatment combinations were replicated thrice. Clusterbean variety RGC-1017 was used as test crop with seed rate of 20 kg ha^{-1} and crop was raised by applying 20 kg N and 40 kg P_2O_5 kg ha^{-1}. All fertilizers were applied at the time of sowing. In each plot two spots were randomly selected for recording the data on weed density and dry matter at 50 DAS using a quadrate measuring 0.5x0.5 m.

The mean data of weed count were subjected to square-root transformation $\sqrt{(x+0.5)}$ to normalize their distribution (Gomez and Gomez, 1984). Different parameters in the study were evaluated following standard procedures.

Results and Discussion

Clusterbean was mainly infested with mixed flora of narrow and broad-leaved weeds viz., *Cynodon dactylon*, *Echinochloa colona*, *Cyperus rotundus*, *Brachiaria reptans, Dinebra retroflexa* and *Dactyloctenium aegyptium* among narrow-leaved weeds and *Amaranthus viridis*, *Commelina benghalensis*, *Digera arvensis*, *Trianthema portulacastrum* and *Physalis minima* among broad-leaved weeds.

Effect on weed count

The count of narrow, broad-leaved and total weeds was significantly reduced by all weed management practices over weedy check at 50 DAS. The minimum weed count was recorded under two hand weeding followed by application of pendimethalin with imazethapyr in sequence with per cent decrease of (86.57and 77.78) and (74.90 and 70.44) narrow and broad-leaved weeds, respectively (Table1.). No significant effect on weed count was observed due to varying sulphur levels during experimentation. Two hand weeding at 20 and 40 DAS was found the most effective in order to reduce the density and dry matter of all categories of weeds at all stages compared to other treatments. This might be due to the fact that removal of weeds twice in the field controlled weeds which emerged during early as well as later stages of crop growth resulted in excellent performance compared to herbicides specially those applied alone.

Table 1: Effect of weed management and sulphur nutrition on weed density and dry weight (50 DAS) in clusterbean

Treatments	Weed density (No m^{-2})			Weed dry weight (g m^{-2})			WCE (%)
	NLW	BLW	Total	NLW	BLW	Total	
Weed Management							
Weedy check	12.28 (150.83)	10.73 (114.86)	16.29 (265.70)	1232	1830	3062	-
One hand weeding	8.91 (79.19)	7.93 (62.56)	11.91 (141.75)	506	933	1439	52.95
Two hand weeding	4.55 (20.26)	4.89 (25.52)	6.64 (43.78)	129	106	235	92.33
Pendimethalin	8.35 (69.32)	8.75 (76.28)	12.08 (145.60)	404	911	1314	56.95
Imazethapyr	7.35 (53.71)	6.27 (39.07)	9.64 (92.78)	378	511	890	70.87
Quizalofop-ethyl	7.96 (63.06)	9.79 (95.04)	12.60 (158.47)	423	1449	1872	38.73
Pendimethalin fb imazethapyr	6.17 (37.86)	5.51 (29.99)	8.24 (67.85)	163	131	295	90.39
Pendimethalin fb quizalofop-ethyl	6.71 (44.58)	7.03 (49.17)	9.69 (93.75)	313	764	1077	64.76
S.Em. ±	0.08	0.09	0.12	10	18	19	
C.d. (P = 0.05)	0.24	0.26	0.36	28	52	54	
Sulphur							
Control	7.74 (64.15)	7.58 (60.86)	10.84 (125.01)	442	821	1263	-
15	7.76 (64.47)	7.60 (61.10)	10.86 (125.58)	444	825	1269	-
30	7.80 (65.24)	7.62 (61.58)	10.90 (126.82)	444	834	1278	-
45	7.83 (65.55)	7.65 (61.80)	10.94 (127.43)	444	838	1282	-
S.Em.±	0.04	0.04	0.05	4	8	11	-
CD (P=0.05)	NS	NS	NS	NS	NS	NS	

*Figures in parentheses are subjected to square-root transformation; NLW; narrow-leaved weeds, BLW; broad-leaved weeds, NS; non sinificant

Effect on weed dry biomass and weed control efficiency

In comparison to weedy check, application of all herbicides and hand weeding resulted in significant reduction in both categories of weeds. Two hand weeding recorded the lowest dry matter which was significantly superior over other treatments but at par with pendimethalin fb imazethapyr. Weed control efficiency based on weed dry matter fluctuated to a great extent under the influence of various weed management treatments at 50 DAS. WCE of narrow-leaved weeds at this stage was the highest under two hand weeding (89.54 per cent) followed by sequential application of pendimethalin with imazethapyr (86.73 per cent) and pendimethalin fb quizalofop-ethyl (74.55 per cent) on mean basis.

Effect on yield attributes

The highest yield attributing characters *viz.,* cluster $plant^{-1}$, pod $cluster^{-1}$, seeds $pods^{-1}$ 1000 seed weight and seed yield $plant^{-1}$ were recorded under two hand weeding followed by sequential application of pendimethalin with imazethapyr. All the weed management treatments significantly influenced all the growth and related parameters compared to weedy check, which in turn increased all the yield attributes viz., cluster $plant^{-1}$, pod $cluster^{-1}$, number of seeds $pods^{-1}$ and 1000 seed weight which ultimately reflected into significantly higher seed and haulm yields (Table 2). Application of sulphur up to 45 kg ha^{-1} significantly increased all yield attributing characters of clusterbean at declining rate. Weed management practices reduced the weed infestation and create condition more favourable for crop. The better expression of yield attributes in herbicides treated and manually weeded plots might be due to poor resurgence frequency and growth of weeds in these treatments. Hence, weeds were unable to compete with the crop plants for different growth factors. Improvement in yield attributes occurred when weeds were controlled in the early growth stages particularly during critical growth period either manually or chemically, which brought down competition and created congenial micro-environment for better establishment and growth of the crop Singh *et al*. (2014) [6] and Godara and Singh, (2015) [1] also reported similar results.

Effect on Yield

All weed management treatment significantly increased seed, haulm and biological yields of clusterbean over weedy check. Critical examination of data reveal that two hand weeding recorded the maximum seed (1218 kg ha^{-1}) and haulm yield (2440 kg ha^{-1}) closely followed by sequential application of pendimethalin with imazethapyr and both of these treatments were found significantly superior over rest of treatments under test. The increased seed and haulm yields and thereby biological yield were obviously the results of better weed management which rendered favourable conditions like increased availability of nutrients, moisture, light and other factors to the crop and resulted in higher yield of clusterbean. These findings corroborate with Rao *et al.* (2015) [3]. Soil enrichment with 45 kg sulphur ha^{-1} showed a significant result in terms of seed, haulm and biological yields of clusterbean with the per cent increase of 28.06, 29.89 and 29.26, respectively compared to control.

Net returns and benefit: cost ratio

Data (Table 2) pertaining to net returns under the influence of weed management treatments indicate that all treatment under test were found significant in achieving net returns compared to weedy check. Data further clarify that pendimethalin fb imazethapyr with maximum net returns of ₹ 36952 found significantly superior over all weed management treatments, except two hand weeding. Application of 45 kg S ha^{-1} registered 9.41, 27.91 and 66.51 per cent increase in net returns over 30 and 15 kg S ha^{-1} and control, respectively. Maximum B C ratio (2.60) was obtained through pendamethalin fb imazethapyr, which was significantly greater than rest of the treatments. On an average, B C ratio obtained through 45 kg S ha^{-1} (2.13) was significantly higher over 30 kg S ha^{-1} (2.03), 15 kg S ha^{-1} (1.88) and control (1.68). The low investment under sequential application coupled with good economic yield might be the reason for higher net monetary returns and BC ratio, even two hand weeding gave maximum gross monetary returns was nullified due to higher variable cost for weed management. Similar findings were also reported by Shruthi and Salakinkop (2015) [5].

Table 2: Effect of weed management and sulphur nutrition on yield attributes, yield and net returns of clusterbean

Treatments	Cluster $plant._1$	Pods $cluster^{-1}$	Seed pod^{-1}	Test weight (g)	Seed yield $plant^{-1}$	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest index (%)	Net returns (₹/ha)	Benefit: cost ratio
Weed Management										
Weedy check	4.22	4.06	4.23	23.10	4.15	410	1170	25.83	1852	1.09
One hand weeding	6.91	4.48	5.51	24.12	5.75	774	1827	29.82	16471	1.71
Two hand weeding	8.92	6.95	7.18	27.77	10.89	1218	2440	33.23	34570	2.29
Pendimethalin	7.18	4.90	5.75	24.90	6.70	806	1899	29.90	19665	1.90
Imazethapyr	7.54	5.25	6.01	25.57	7.70	840	1919	30.55	21208	1.97
Quizalofop-ethyl	5.98	4.31	5.42	24.15	5.23	675	1626	29.42	12913	1.59
Pendimethalin fb imazethapyr	8.70	6.27	6.83	27.87	10.32	1188	2402	33.16	36952	2.60
Pendimethalin fb quizalofop-ethyl	8.30	5.83	6.19	27.14	8.78	1047	2253	31.90	30154	2.30
S.Em. ±	0.12	0.10	0.10	0.44	0.16	17	38	0.74	754	0.03
C.d. (P = 0.05)	0.35	0.30	0.30	1.28	0.46	50	110	2.13	2183	0.09
Sulphur										
Control	6.02	4.48	5.08	21.91	4.72	752	1663	30.61	15831	1.68
15	7.02	5.05	5.76	25.00	6.64	847	1892	30.33	20609	1.88
30	7.68	5.56	6.19	27.05	8.40	917	2053	30.48	24093	2.03
45	8.15	5.93	6.54	28.35	10.00	963	2160	30.49	26360	2.13
S.Em.±	0.08	0.05	0.06	0.28	0.10	10	21	0.30	475	0.02
CD (P=0.05)	0.23	0.15	0.17	0.77	0.27	29	58	NS	1335	0.06

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