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Production of Fenugreek (*Trigonella foenum-graecum*) as Influenced by Weed Management Practices and Vermicompost Application

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ABSTRACT

Background: A field experiment was conducted at the Instructional Farm of Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur during *Rabi* 2016-17 and 2017-18 to study the weed flora, growth, yield and economics of fenugreek. The experiment was laid out in split plot design with three replications having Fenugreek variety RMT-305 (25 kg ha^{-1}) and RDF of 40 kg N and 40 kg P_2O_5 ha^{-1} (basal dose through urea and DAP).

Methods: Herbicide applied as pre-emergence (PE) at one day after sowing, while post-emergence (PoE) application at 2-4 leaf stage of weeds (21 DAS) with knapsack sprayer having flat fan nozzle using 500 liters of water ha^{-1}.

Result: The pooled results revealed that pre-emergence application of oxadiargyl 100 g/ha *fb* hoeing at 40 DAS recorded significantly higher weed control efficiency (82.3%), plant height (59.83 cm), number of branches (6.09), number of pods (44.86), number of seeds/pod (17.33), seed weight (9.05 g/plant) of fenugreek. Also, significantly maximum seed yield (2.82 t/ha), haulm yield (6.70 t/ha) and harvest index (29.7%) of fenugreek was recorded under oxadiargyl 100 g/ha PE *fb* hoeing at 40 DAS which was at par with weed free treatment. Significantly higher net returns (98158 ₹/ha) and B: C ratio (2.63) was obtained with application of oxadiargyl 100 g/ha Pre-Emergence (PE) *fb* hoeing at 40 DAS. Residual effect of herbicides used in fenugreek did not showed any phytotoxic effect on succeeding summer fodder maize in terms of visual phytotoxicity rating at various growth stages of maize, weed flora, dry matter of weeds as well as crop at 30 DAS and green fodder yield of summer fodder maize.

Key words: Fenugreek, Oxadiargyl, Weed control efficiency, Weed density.

INTRODUCTION

Fenugreek (*Trigonella foenum-graecum* L.) is most valuable seed spices of semi-arid region of the country. India occupies prime position among the fenugreek growing countries of the world with 2.1 lakh ha area and 2.97 lakh metric tonnes (Agriculture Statistics at a Glance, 2018). In India, it is mainly grown in Rajasthan, Gujarat, Utter Pradesh and Tamil Nadu. Among the states, Rajasthan is the largest fenugreek growing state which contributes 56.39 per cent of total production and occupies an area of 1.29 lakh hectare with the production of 1.57 lakh tonnes during 2016-17 (Agriculture Statistics at a Glance, 2017).

The yield of this crop lowered by many factors, among these weed infestation appears to be the most important one. Weeds have been identified as a serious drawback since they create the biotic stress in realizing the genetic yield potential of this crop. Weeds cause enormous losses (37%) due to their interference compared to insect pests and diseases (Verma *et al*., 2015). Weeds reduced the grain yield of this crop upto an extent of 86% (Tripathi and Singh, 2008). Weeds offered maximum competition up to 25-30 days of sowing in fenugreek resulting in drastic reduction in the seed yield. Manual weeding at right stage is difficult because of laborious and time consuming and expensive in nature. Under such conditions, use of herbicide with suitable dose remains the pertinent choice for controlling the weeds. In present study imazethapyr + imazamox (Ready Mix), oxyfluorfen and oxydiargyl have been taken for testing at different doses for control of diversified weed flora along with pendimethalin and imazethapyr. Sometimes, herbicide alone is not able to complete weed control. Their use can be made more effective, if supplemented with hand weeding or hoeing or sequential application of herbicides. A judicious combination of chemical and cultural methods of weed control would not only reduce the expenditure on herbicides but would benefit the crop by providing aeration and conservation of moisture. Keeping the above fact, the investigation was undertaken to study the response of different weed management practice and vermicompost on growth, yield and economics of fenugreek under agro-climatic zone IV-a (sub humid southern plains and Aravalli hills) of Rajasthan.

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MATERIALS AND METHODS

A field experiment was conducted at the Instructional farm of the Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology Udaipur during winter seasons of 2016-17 and 2017-18. Thirteen weed management treatments comprising imazethapyr 70 ha^{-1}, imazethapyr 70 g ha^{-1} followed by (*fb*) hoeing at 40 days after sowing (DAS), imazethapyre 50 g ha^{-1} at 2-4 leaf stage of weeds, imazethapyr + imazamox 50 and 60 g ha^{-1} at 2-4 leaf stage of weeds, pendimethalin 750 g ha^{-1} PE, Oxyfluorfen (120 and 150 g ha^{-1} and 120 g ha^{-1} *fb* hoeing at 40 DAS), oxadiargyl (100 g ha^{-1} and 100 g ha^{-1} *fb* hoeing at 40 DAS) including weed free and weedy check in main plot treatments and levels of vermicompost-*viz*., control and 5 t ha^{-1} in sub plot treatments. The experiment was laid out in split-plot design with three replications. The soils of experimental field were clay loam in texture slightly alkaline in reaction with pH of 8.1 medium in organic carbon (0.71%), available nitrogen (285 kg ha^{-1}), available phosphorus (19.42 kg ha^{-1}) and high in available potassium (344.16 kg ha^{-1}). Fenugreek variety RMT305 was sown at 30 cm distance with 25 kg ha^{-1} seed rate and recommended dose of fertilizers (40 kg N and 40 kg P_2O_5 ha^{-1}) was applied as basal dose through urea and DAP. As per treatment, pre-emergence application of herbicide was sprayed one day after sowing, while post-emergence application of herbicide was applied at 2-4 leaf stage of weeds (21 DAS). The herbicides were sprayed with knapsack sprayer fitted with flat fan nozzle using 500 liters of water per hectare after its calibration.

The crop was harvested at physiological maturity when plants turned golden yellow. Theharvested produce kept for sun drying for a period of seven days. The dried bundles were weighed to record the total biological yield. After threshing, winnowing and cleaning was done and seeds were weighed separately to record seed yield kg $plot^{-1}$ and yield expressed in terms of kg ha^{-1}. The harvest index (HI) was calculated by formula as given by Donald and Hamblin (1976). All the data were subjected to statistical analysis by adopting appropriate method of analysis of variance as described by Cocharan and Cox (1967).

RESULTS AND DISCUSSION

Weed flora

The experimental field was infested with weeds comprised of both monocot as well as dicots. Among the total weeds dicot weeds were more prominent (89.75%) compared to monocots (11.25%). The weed flora under dicots includes *Chenopodiun album* L., *Chenopodiun murale* L., *Fumeria parviflora* L., *Malva parviflora* L., *Melilotus indica* L. and *Convolvulus arvensis* L. where as; *Phalaris minor* Retz was only grass weed under monocots.

Weed density, weed dry matter and weed control efficiency

All the weed management treatments significantly reduced the weed density and weed dry matter over crop kept weedy (Table 1). Among the weed management treatments oxadiargyl 100 gha^{-1} pre-emergence (PE) followed by (*fb*) hoeing at 40 days after sowing (DAS) recorded the lowest weed density and dry matter (24.25 m^{-2} and 158.22 g m^{-2}) which was significantly superior over other treatments including weedy check (158.42 m^{-2} and 893.44 m^{-2}). This might be due to the fact that broad spectrum contact herbicide used mainly as a pre-emergence controlled early flushes of weeds as well as late flushes of weeds up to the most critical stage of crop-weed competition due to the persistence and prolonged activity in the soil and later hoeing at 40 DAS controlled late flushes of weeds resulting in excellent performance compared to herbicides specially applied alone or as pre or post-emergence. The correlation studies also showed a well-established significant negative correlation between seed yield and weed dry matter at harvest with the respective value of r = -0.789. The superiority of herbicide in integration with hoeing or weeding at 40 DAS was also been reported by Singh *et al*. (2013), Singh *et al*. (2014), Kumar *et al*. (2016), Punia and Tehlan (2017).

Application of vermicompost- resulted in higher dry matter accumulation by weeds (352.92 g m^{-2}) over control (313 g m^{-2}) which was 24.65% higher over control on pooled basis. It was due to better nutritional environment in plants under the influence of vermicompost seems to have promoted growth of individual leaf by way of active cell division and their elongation. The better canopy development could be reason for increased interception, absorption and utilization of solar energy which in turn increased photosynthetic ability of plant finally leads to increased dry matter accumulation at successive growth stages in accordance with the findings of Shivran *et al*. (2016) and Vasava *et al*. (2019).

The efficacy of herbicides estimated on the basis of weed dry matter (Table 1). Different weed management treatments recorded weed control efficiency from 52.83 to 82.30 per cent. The highest weed control efficiency was due to application of oxadiargyl 100 g ha^{-1} *fb* hoeing at 40 DAS resulting into monocot (91.27%), dicot (80.66%) and total weeds (82.30%). Among alone herbicide application oxadiargyl 100 g ha^{-1} (73.48%) followed by imazethapyr 50 g ha^{-1} (Post-emergence PoE) recorded (66.00%) higher over other treatments.

Yield attributes and yield

The significantly higher number of pods $plant^{-1}$ and seed weight $plant^{-1}$ (48.01 and 9.26) was recorded in weed free check (Table 2) which remained statistically at par with oxadiargyl 100 gha^{-1} *fb* hoeing at 40 DAS (44.86 and 48.50) over rest of the treatments. This can be attributed to the reduced weed density and dry matter which resulted into higher weed control efficiency and lesser nutrient mining altogether with lesser degree of competition for other growth resources (moisture, space and light). Weed management practices reduced the weed infestation and create condition more favorable for crop growth. Tiwari *et al*., (2006), Mehta *et al*., (2010), Bagotiya *et al*., (2018), Singh *et al*. (2013) Singh *et al*. (2014) and Kumar *et al*., 2016 also reported that treatment combination of Vermicompost 2 t/ha with hand weeding carried out at 20 and 40 DAS was found effective in reducing density as well as weed dry biomass of weeds.

Table 1: Effect of weed management and vermicompost on category wise weed density, dry matter and weed control efficiency in fenugreek at harvest (Pooled data of two years).

Treatments	Weed density (m^{-2})			Weed dry matter (g m^{-2})			Weed control efficiency (%)		
	Monocot	Dicot	Total	Monocot	Dicot	Total	Monocot	Dicot	Total
Weed management									
Imazethapyr 70 g ha^{-1} PE	4.68 (21.58)	7.13 (50.33)	8.50 (71.92)	84.73	353.33	438.07	38.65	53.25	51.00
Imazethapyr 70 g ha^{-1} PE *fb* hoeing at 40 DAS	1.85 (3.00)	5.50 (29.58)	5.76 (32.75)	16.50	210.92	227.42	88.05	72.09	74.56
Imazethapyr 50 g ha^{-1} PoE 2-4 leaf stage of weed	4.58 (20.67)	5.69 (31.81)	7.27 (52.53)	95.32	208.54	303.85	30.99	72.40	66.00
Imazethapyr + Imazamox (RM) 50 g ha^{-1} PoE 2-4 leaf stage of weed	4.48 (19.83)	6.81 (46.00)	8.13 (65.83)	82.11	286.31	368.42	40.55	62.14	58.81
Imazethapyr + Imazamox (RM) 60 g ha^{-1} PoE 2-4 leaf stage of weed	4.09 (16.50)	6.45 (41.16)	7.61 (57.66)	71.31	249.72	321.04	48.37	66.95	64.08
Pendimethalin 750 g ha^{-1} PE	5.05 (25.00)	6.44 (41.08)	8.15 (66.08)	121.41	222.97	344.38	12.10	70.50	61.47
Oxyfluorfen 120 g ha^{-1} PE	3.18 (9.75)	7.51 (56.01)	8.13 (65.76)	50.52	371.18	421.69	63.43	50.89	52.83
Oxyfluorfen 150 g ha^{-1} PE	2.55 (6.25)	7.01 (48.76)	7.43 (55.01)	23.19	315.76	338.95	83.21	58.22	62.08
Oxyfluorfen 120 g ha^{-1} PE *fb* hoeing at 40 DAS	1.64 (2.18)	5.91 (34.50)	6.10 (36.68)	13.51	261.98	275.49	90.22	65.33	69.18
Oxadiargyl 100 g ha^{-1} PE	2.71 (6.94)	5.87 (34.03)	6.55 (42.46)	33.27	204.21	237.48	75.91	73.04	73.48
Oxadiargyl 100 g ha^{-1} PE *fb* hoeing at 40 DAS	1.49 (1.75)	4.79 (22.50)	4.79 (24.25)	12.06	146.16	158.22	91.27	80.66	82.30
Weed free check	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.00	0.00	0.00	100.00	100.00	100.00
Weedy check	5.49 (29.67)	14.70 (215.75)	15.68 (245.42)	138.12	755.32	893.44	0.00	0.00	0.00
SEm±	0.02	0.04	0.04	1.02	4.14	5.08			
CD (P=0.05)	0.05	0.11	0.11	3.14	12.77	15.66			
Levels of vermicompost									
Control	3.27(12.55)	6.52(50.41)	7.32(62.96)	53.75	259.24	313.00			
Vermicompost 5 t ha^{-1}	3.27(12.54)	6.50(50.09)	7.30(62.63)	60.41	292.51	352.92			
SEm±	0.01	0.02	0.02	0.41	1.54	1.84			
CD (P=0.05)	NS	NS	NS	1.16	4.36	5.20			

Values are $\sqrt{X+0.5}$ transformed and actual values are in parentheses. PE (Pre-emergence), PoE (Post emergence), RM (Ready Mix).

Table 2: Effect of weed management and vermicompost on yield and economics of fenugreek (Pooled data of two years).

Treatments	Pods plant^{-1}	Seed weight (g plant^{-1})	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest index (%)	Net return (₹ ha^{-1})	B:C ratio
Weed management							
Imazethapyr 70 g ha^{-1} PE	34.21	6.13	1897	5712	24.81	61715	1.94
Imazethapyr 70 g ha^{-1} PE *fb* hoeing at 40 DAS	41.44	8.45	2260	6122	26.88	73940	2.04
Imazethapyr 50 g ha^{-1} PoE 2-4 leaf stage of weed	40.75	7.16	2132	6132	25.72	73487	2.36
Imazethapyr + Imazamox (RM) 50 g ha^{-1} PoE 2-4 leaf stage of weed	39.47	6.89	2102	6161	25.29	70756	2.23
Imazethapyr + Imazamox (RM) 60 g ha^{-1} PoE 2-4 leaf stage of weed	40.81	7.19	2162	5174	29.37	71689	2.24
Pendimethalin 750 g ha^{-1} PE	35.70	6.24	2004	6031	24.87	64196	1.87
Oxyfluorfen 120 g ha^{-1} PE	33.91	5.84	1837	5342	25.60	57710	1.87
Oxyfluorfen 150 g ha^{-1} PE	35.13	6.19	1976	4916	28.62	63010	2.02
Oxyfluorfen 120 g ha^{-1} PE *fb* hoeing at 40 DAS	41.29	6.97	2114	5377	28.17	66421	1.85
Oxadiargyl 100 g ha^{-1} PE	41.05	7.46	2216	5337	29.27	74352	2.30
Oxadiargyl 100 g ha^{-1} PE *fb* hoeing at 40 DAS	44.86	9.05	2820	6703	29.66	98158	2.63
Weed free check	48.01	9.26	2908	6863	29.97	96532	2.19
Weedy check	24.60	4.52	1055	4220	20.09	21774	0.87
SEm±	1.81	0.10	31	68	0.16	1544	0.05
CD (P=0.05)	5.29	0.32	95	209	0.49	4756	0.14
Levels of vermicompost							
Control	35.45	6.48	1880	5539	25.13	73023	2.90
Vermicompost 5 t ha^{-1}	41.66	7.58	2348	5860	28.46	64475	1.16
SEm±	0.47	0.06	18	44	0.18	816	0.03
CD (P=0.05)	1.36	0.16	50	125	0.51	2304	0.08

Note: PE (Pre-emergence), PoE (Post emergence), RM (Ready mix).

It is obvious from the pooled estimates of investigation that application of vermicompost resulted in significantly higher pods plant^{-1}and seed weight plant^{-1}.

The significantly higher seed and haulm yield (Table 2) were recorded in weed free check (2908 and 6863 kg ha^{-1}) which was followed by oxadiargyl 100 g ha^{-1} *fb* hoeing at 40 DAS (2820 and 6703 kg ha^{-1}) and superior over rest of the treatments. The significantly higher harvest index (Table 2) was recorded in weed free (29.97%) followed by oxadiargyl 100 g ha^{-1} *fb* hoeing at 40 DAS (29.66%) was statistically at par with each other and significantly higher over other treatment. Improvement in yield attributes was possible when weeds were controlled in the early growth stages particularly during critical crop-weed completion period. Integration of physical and chemical method of weed control brought down competition and created better environment for satisfactory growth of the crop.In the present study significant and positive correlation between seed yield and pods plant^{-1}, 1000-seed weight, number of seeds pod^{-1} and seed weight plant^{-1} with respective values of r = 0.955, 0.825, 0.837 and 0.952 validate the profound effect of these parameters on the seed yield. The regression studies also suggest that each unit increase in these parameters was responsible for 72, 869, 922 and 338 kg ha^{-1} increased in theseed yield. These results are in close conformity with the findings of Mehta *et al*. (2010), Singh *et al*. (2013), Verma *et al*., 2017, Singh *et al*. (2014) and Kumar *et al*. (2016). The yield was increased significantly by alone application of imazethapyr (PoE) and imazethapyr + imazamox (PoE) over weedy check.

It is evident from the data that application of vermicompost significantly increased the seed yield (2348 and 5860 kg ha^{-1}) which was 24.93 and 5.80 per cent higher over the weedy check (1880 and 5539 kg ha^{-1}). Based on the pooled mean, the significantly higher harvest index was recorded with the application of vermin compost (28.46%) over control (25.13%). The increase in seed and haulm yield with application of vermicompost might be due to better availability of nutrients in the soil, nutritional status of the crop and increased accumulation of photosynthates and their remobilization to reproductive parts of the plants, being the closest sink and hence, resulted in increased flowering, fruiting and seed formation. Thus, such results also corroborate with the findings of Singh and Singh (2005), Dubey *et al.* (2012) and Dhaker *et al.* (2015).

Economics

Among various weed management practices, the higher net returns (Table 2) were obtained inoxadiargyl *fb* hoeing at 40 DAS (₹ 98158 ha^{-1}) which was significantly superior over other weed control treatments but was statistically at par with weed free check (₹ 96532 ha^{-1}). Among alone herbicides,

higher net returns were obtained by controlling weeds with oxadiargyl 100 g ha^{-1} (₹ 74352 ha^{-1}). The application of oxadiargyl *fb* hoeing at 40 DAS recorded higher B:C ratio 2.63 which was significantly superior over other weed control treatments. Lowest B:C ratio 0.87 was recorded (Table 2) in weedy check on pooled basis. Similar findings were also reported by Meena *et al.* (2013), Singh *et al.* (2013), Singh *et al.* (2014) and Kumar *et al.* (2016). The maximum net return and BCR was recorded with two hand weeding at 20 and 40 DAS which were at par with each other and significantly higher over rest of the weed management treatments.

Application of vermicompost to fenugreek crop resulted into lower net returns (₹ 64475 ha^{-1}) as compared to control (₹ 73023 ha^{-1}). Similarly, application of vermicompost 5 t ha^{-1} to fenugreek resulted into lower B:C ratio 1.10 as compared to control (2.79). The results obtained in the present study are in close agreement with Singh *et al.,* (2015).

CONCLUSION

Herbicides have been identified as an indispensable part of the crop production programme. Weed control through herbicides application contributed immensely to the growth and yield of fenugreek by reducing the competition offered by weed growth. Therefore, on the basis of pooled estimates pre-emergence application of oxadiargyl 100 g ha^{-1} followed by hoeing at 40 DAS was proved superior in effective weed management, the higher weed control efficiency and higher seed yield and economics of fenugreek.Integrated nutrient management of 5 t ha^{-1}vermicompost along with 40 kg N and 40 kg P can be achieved by the use of vermicompost prepared by the same farm family on a farm itself in order to minimize the cost of production.

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