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Effect of integrated nutrient management and weed control measures on weed density, weed dry matter, yield and nutrient content in mustard and its residual effect on fodder pearl millet

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Abstract
An experiment were conducted during the years of 2014-15 and 2015-16 at Bikaner, to evaluate the integrated nutrient management and weed control measures on mustard (*Brassica juncea* L.) and its residual effect on fodder pearl millet (*Pennisetum glaucum* L). The highest density and dry matter of different weeds like as *Chenopodium* species, *Rumex dentatus, Melilotus indica* and total weeds was observed under the treatment where the nutrient was supplied through FYM. The significantly growth attributes and yield was observed under the treatment of 5 t FYM + 100% RDF which was statistically at par with t FYM + 75% RDF + biofertilizer. Significantly maximum N, P and K content was observed under the all nutrient management treatments over control. Application of INM have residual effect and increased the fodder yield of pearl millet over control and 100% RDF, treatments applied in preceding mustard.

Keywords: integrated nutrient management, weed control measures, fodder pearl millet

Introduction
Rapeseed-mustard [*Brassica juncea* (L.) Czern & Coss.] is the third most important edible oilseed crop in India after soybean and groundnut. It is mainly used for its oil throughout Northern India. It is also used in the preparation of hair oils, medicines, soap and mixed with mineral oils for lubrication and in manufacture of grease. The seed is also used as condiment in the preparation of pickles and in vegetables for flavoring curries. In India, it is grown on 6.45 million hectare, with an annual production of 6.82 million tonne during 2015-16 (Anonymous, 2015-16a) [1, 2]. Rajasthan is one of the major mustard producing states in the country, with an annual production of 3.37 million tonne and area 2.38 million hectare during 2015-16 (Anonymous, 2015-16b) [1, 2]. It contributes 49.4 percent in total production of the country. National and state productivity of mustard in 2015-16 were 1057 kg ha^{-1} and 1415 kg ha^{-1}, respectively (Anonymous, 2015-16a) [1, 2].

Pre-emergence herbicides are mainly used in mustard to control weeds. Farmers and extension functionaries are emphasizing for post-emergence herbicidal weed control due to one or other reasons. So there is a need to explore the possibility of using post emergence herbicides in mustard. Under the situation where weeds are not completely taken care by pre-emergence application of herbicides, the post-emergence herbicides may have an added economic advantage over super imposition of hand weeding. Therefore, it is imperative to find out an alternative weed management strategy for achieving season long weed control in Indian mustard.

Farmers in North-Western Rajasthan rear livestock for their livelihood support. Green fodder shortage particularly in summer months is most common. Except pearl millet, no other fodder is grown because of harse climate during summer months (April to June). Farmers in general are cultivating fodder pearl millet under limited availability of water condition of this region during summer. As organic matter present in soil in this area get oxidized very fast due to high temperature, it is very difficult to save residual nutrients up to *kharif* season.

Materials and methods

A field experiment was conducted during the winter season of 2014-15 and 2015-16 at College of Agriculture, SK Rajasthan Agriculture University Bikaner. The average annual rainfall of the tract is about 260 mm which is mostly received during the rainy season. Soils are loamy sand with 0.11% organic carbon, 116.3 kg ha^{-1} N, 18.2 kg ha^{-1} P_2O_5 and 242.3 kg ha^{-1} K_2O. The experiment consisting of 6 nutrient management treatments viz. control, 100% of RDF, 5 t FYM + 75% of RDF, 5 t FYM + 100% of RDF, 5 t FYM + 50% of RDF+ biofertilizer (*Azospirillum* and PSB) and 5 t FYM + 75% of RDF+ biofertilizer (*Azospirillum* and PSB) and 5 weed management treatments viz. Weedy Check, weed free, pendimethalin (1.0 kg ha^{-1}) pre emergence, Quizalofop-ethyl (60 g ha-1) Post emergence at 25 DAS and Pendimethalin (750 g ha^{-1}) PE+ Quizalofop-ethyl (45 gha^{-1}) POE at 25 DAS was laid out the split plot design. The recommended dose of fertilizer was 90 kg N, 40 kg P_2O_5 and 20 kg K_2O. Half dose of nitrogen and full dose of phosphorous and potassium was applied basal at the time of sowing. Remaining nitrogenous fertilizer was applied in 2 equal splits – at 25 and 45 DAS in mustard. The mustard RGN 48 was sown at 30 cm row spacing on 6th and 2nd November during 2014 and 2015, respectively and harvested on date 16th and 10th march 2015 and 2016, respectively. After harvest of mustard, soil status were taken for soil analysis. Succeeding fodder pearl millet variety RCB 2 was sown on 10th and 4th April 2015 and 2016, respectively. After prepared field in the same layout to the residual effect of integrated nutrient management and weed control measures during summer season.

The data on density and dry matter of total weeds randomly placing two quadrates (0.5 x 0.5 m) per plot and converted in m^2. The dry weight of weeds was recorded by keeping the weeds in oven at 70° C till constant weight was achieved. The seed yield of each net plot (inclusive of tagged plants) was recorded in kg $plot^{-1}$ after cleaning the threshed produce and was converted as kg ha^{-1}. Soon after cutting of pearl millet plants, the produce of each plot was weighed. The weight was recorded as green fodder yield (kg per plot). The yield per plot was then converted into t ha^{-1}.

Plant samples of seed and straw of mustard crop collected at harvesting were dried in hot air oven at 65^0 for 48 h. The N, P and K were estimated as per the standard methods. The uptake of nutrients was computed by multiplying the concentration with seed yield, straw yield of mustard and dry fodder yield of fodder pearl millet.

Results and discussion

Effects on weeds

Integrated nutrient management

The experiment field was infested with *Chenopodium album, Chenopodium murale, Rumex dentatus and Melilotus indica.* The effect of integrated nutrient management practices on different weeds were significant (Table 1). The significantly higher and maximum density of *Chenopodium species, Rumex dentatus, Melilotus indica* and total weeds at 25, 40 and harvest was obtained with all the FYM applied treatments over the control and 100% RDF. Application of the integrated nutrient management did not significantly differ with each other, all the integrated nutrient management treatments statistically at par with each other. The dry matter of the weeds like *Chenopodium species, Rumex dentatus, Melilotus indica* and total weeds significantly higher over control and 100% RDF under the treatment where FYM were added. Application of all the integrated nutrient management treatments statistically at par with each other. The application of organic manures mainly FYM to the crops might have resulted in higher weed frequency as the organic manures might have brought weed seeds with them and/or made soil conditions favourable for weed emergence. These findings are in conformity with those reported Kumar *et al*. (2011) [5]

Weed control measures

Pendimethalin 1.0 kg ha^{-1} and pendimethalin 750 g + quizalofop-ethyl 45 g ha^{-1} significantly reduced the density of *Chenopodium species, Rumex dentatus, Melilotus indica* and total weeds over weedy check and quizalofop-ethyl 60 g ha^{-1} at 25, 40 DAS and harvest. Pendimethalin 1.0 kg ha^{-1} and pendimethalin 750 g + quizalofop-ethyl 45 g ha^{-1} significantly reduced the dry matter of *Chenopodium species, Rumex dentatus, Melilotus indica* and total weeds over weedy check and quizalofop-ethyl 60 g ha^{-1} at 25 and harvest. Pendimethalin 1.0 kg ha^{-1} superior in control of weeds to all weed control measures. The quizalofop-ethyl 60 g ha^{-1} failed to control the broad leaved weeds. Quizalofop-ethyl alone or in combination with pendimethalin had poor weed control under total density of weeds (Table 1) in the present study. It generally inhibits microtubule assembly during cell division. The inhibition of root growth is a direct and the most spectacular observable symptom following its root absorption. Reduced shoot growth is probably a secondary effect caused by limited root growth. Pendimethalin is known to be adsorbed by germinating weeds and disrupts the cell division, especially mitotic process mostly in meristematic tissue of weeds which are responsible for lateral and secondary root formation (Ashton and crafts, 1973) [3]. Hence, thus it is fairly conceivable that such inhibitory effects of pendimethalin might have reduced the weed population and weed dry matter production. As quizalofop-ethyl control only monocot grassy weeds (Tamang *et al*. 2015) [8] hence treatments involved quizalofop-ethyl alone or in combination with pendimethalin had poor weed control under total weeds (Table 1 and 2). In the present study, the dicot weeds were dominating than monocots.

Effect on crop

Integrated nutrient management

Mustard seed and straw yield were significantly higher with the application of different nutrient management sources than control (Table 3) The maximum and significantly higher seed and straw yield was recorded with application of 5 t FYM + 100% RDF but it was statically at par with 5 t FYM + 75% of RDF + biofertilizer and significantly higher over rest of the treatments. The favourable effect of conjunctive use of FYM with inorganic fertilizers on seed yield was due to more yield attributes. The yield advantage of integration of organic sources with inorganic fertilizers and also biofertilizer form associative symbiosis with plants. The increase in straw yield with INM could be partly attributed to its direct influence on dry matter production of each vegetative part and indirectly through increased morphological parameters of growth. All integrated nutrient management significantly increased the nitrogen, phosphorus and potassium content in seed and straw over control. The maximum N,P and K content was obtained under the treatment 5 t FYM+ 100% RDF which was at par with all fertilizer applied treatments. The positive influence of FYM and inorganic fertilizer application on nutrient content in mustard appears to be due to improved nutritional level both in the root zone and plant system. The increased availability of these nutrients in root zone coupled with increased metabolic activity at cellular level might have

increased nutrient uptake (Table 3) and their accumulation in vegetative plant parts. Increased accumulation of nutrients in vegetative plant parts with improved metabolism led to greater translocation of these nutrients to reproductive organs of the crop and ultimately increased the contents in seed and straw, similar findings recorded by Regar *et al.* (2009) [6], Singh and Pal (2011) [7].

Weed control measures

Seed and straw yield was recorded under pendimethalin 1.0 kg ha^{-1} which was at par with pendimethalin 750 g ha^{-1} + quizalofop-ethyl 45 g ha^{-1} in comparison to quizalofop-ethyl 60 gha^{-1} POE and weedy check treatment. Pendimethalin 1.0 kg ha^{-1} treatment was statistically at par weed free treatment. The lowest seed and straw yield was recorded under weedy check and quizalofop-ethyl 60 g ha^{-1}. The lowest value of yield may be due to severe competition by weeds for resources, which made the crop plant incompetent to take up more moisture and nutrients, consequently growth was adversely affected (Kour *et al.* 2014 and Singh *et al.* 2013) [4, 10] The N, P and K content did not affect significantly, it may be due to the dilution effect.

Residual effect

The Integrated Nutrient Management treatment applied in mustard have significant residual effect on the yield of succeeding fodder pearl millet (Table 4). All the INM treatments significantly increased the green and dry fodder yield of pearl millet over control and 100% RDF. Since manure like FYM is known to have residual effect on succeeding crops up to 2-3 seasons, the beneficial effect of INM treatments on yield of succeeding crop of fodder pearl millet might be due to its contribution in supplying additional plant nutrients and its capacity to improving solubility of native soil nutrients. Application of organic manure *viz* FYM in mustard did not influence nutrient content of N, P and K in dry fodder of pearl millet, this might be due to the dilution effect of nutrients in succeeding pearl millet

This was no significant variation obtained in yield N, P and K content in dry fodder weed control treatments applied in mustard on succeeding fodder pearl millet in summer season (Sharma *et.al.* 2014) [9].

Table 1: Effect of integrated nutrient management and weed control measures on weed density (no.m^{-2}) of different weeds in mustard (pooled data of 2 years)

Treatments	*Chenopodium* species		*Rumex dentatus*			*Melilotus indica*					Total density		
	25 DAS	40 DAS	At harvest	25 DAS	40 DAS	At harvest	25 DAS	40 DAS	At harvest	25 DAS	40 DAS		At harvest
Integrated nutrient management													
Control	4.61 (26.80)	5.28 (34.70)	4.57 (25.86)	2.49 (6.85)	2.85 (9.31)	2.59 (7.48)	2.28 (5.60)	2.49 (6.92)	1.94 (3.86)	5.99 (44.98)	6.81 (58.17)		5.86 (42.79)
100% RDF	5.06 (32.28)	5.60 (38.92)	4.83 (28.95)	2.68 (8.06)	3.04 (10.63)	2.76 (8.66)	2.48 (6.83)	2.66 (7.99)	2.12 (4.73)	6.52 (53.57)	7.25 (65.82)		6.29 (49.30)
5 t FYM +75% RDF	5.34 (35.71)	6.03 (45.48)	5.11 (32.50)	2.81 (9.00)	3.41 (13.66)	3.03 (10.58)	2.77 (8.76)	2.80 (8.92)	2.31 (5.75)	6.99 (61.48)	7.88 (78.08)		6.77 (57.25)
5 t FYM +100% RDF	5.45 (37.17)	6.09 (46.46)	5.15 (33.00)	2.90 (9.58)	3.43 (13.86)	3.09 (10.97)	2.83 (9.12)	2.83 (9.07)	2.34 (5.90)	7.16 (64.38)	7.96 (79.77)		6.85 (58.62)
5 t FYM + 50% RDF + biofertilizer	5.32 (35.46)	6.03 (45.39)	5.09 (32.30)	2.79 (8.87)	3.40 (13.61)	3.00 (10.40)	2.76 (8.69)	2.79 (8.84)	2.29 (5.66)	6.95 (60.97)	7.86 (77.77)		6.73 (56.68)
5 t FYM + 75% RDF + biofertilizer	5.38 (36.40)	6.08 (46.29)	5.13 (32.73)	2.84 (9.16)	3.42 (13.81)	3.04 (10.65)	2.80 (9.00)	2.82 (9.01)	2.33 (5.87)	7.06 (62.85)	7.94 (79.32)		6.81 (57.91)
SEm±	0.07	0.09	0.05	0.04	0.05	0.03	0.03	0.03	0.03	0.08	0.09		0.06
CD (P=0.05)	0.22	0.27	0.15	0.11	0.14	0.10	0.09	0.09	0.08	0.25	0.25		0.17
Weed control measures													
Weedy Check	7.96 (63.23)	8.78 (76.95)	7.60 (57.44)	4.01 (15.62)	4.79 (22.64)	4.24 (17.63)	3.84 (14.44)		3.96 (15.21)	3.14 (9.43)	10.37 (107.5)	11.53 (133.1)	9.94 (98.77)
Weed free	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)		0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
Pendimethalin 1.0 kg ha^{-1} PE	4.18 (17.13)	4.97 (24.39)	3.98 (15.44)	2.40 (5.31)	2.79 (7.36)	2.47 (5.66)	2.19 (4.36)		2.33 (4.95)	1.89 (3.11)	5.87 (34.25)	6.79 (45.92)	5.70 (32.17)
Quizalofop-ethyl. 60 g ha^{-1} at 25 DAS	7.95 (62.90)	8.76 (76.54)	7.48 (55.67)	3.93 (15.06)	4.69 (21.73)	4.17 (17.05)	3.81 (14.23)		3.94 (15.11)	3.12 (9.31)	10.03 (100.7)	11.12 (123.8)	9.54 (90.93)
Pendi. (750 g ha^{-1}) PE+ Q.E. (45 g ha^{-1}) at 25 DAS	5.18 (26.59)	6.06 (36.48)	5.13 (25.91)	2.72 (6.94)	3.32 (10.66)	3.00 (8.60)	2.72 (6.98)		2.74 (7.02)	2.25 (4.63)	6.92 (47.72)	7.94 (62.97)	6.87 (46.92)
SEm±	0.07	0.08	0.06	0.04	0.05	0.04	0.05		0.22	0.03	0.08	0.08	0.05
CD (P=0.05)	0.19	0.23	0.16	0.11	0.15	0.12	0.15		0.63	0.09	0.21	0.24	0.15

Weed density transformed to $\sqrt{x + 0.5}$, Figures in parenthesis are original value, Q.E. = Quizalofop-ethyl

Table 2: Effect of integrated nutrient management and weed control measures on dry matter of different weeds (g m^{-2}) in mustard (pooled data of 2 years)

	Chenopodium species		*Rumex dentatus*	*Melilotus indica*			Total density	
	25 DAS	At harvest	25 DAS	At harvest	25 DAS	At harvest	25 DAS	At harvest
Integrated nutrient management								
Control	2.44	8.03	0.36	14.77	0.24	3.39	3.35	31.58
100% of RDF	3.01	9.07	0.42	16.89	0.28	3.95	4.09	35.97
5 t FYM +75% of RDF	3.33	10.21	0.47	18.38	0.32	4.45	4.56	39.80
5 t FYM +100% of RDF	3.42	10.55	0.50	19.30	0.33	4.65	4.70	41.49
5 t FYM+50% of RDF+ biofertilizer	3.30	9.91	0.46	17.96	0.31	4.35	4.50	38.92
5 t FYM+75% of RDF+ biofertilizer	3.39	10.38	0.48	18.92	0.32	4.56	4.64	40.92
SEm±	0.07	0.31	0.01	0.51	0.01	0.13	0.08	0.88
CD (P=0.05)	0.21	0.93	0.04	1.50	0.03	0.38	0.22	2.61
Weed control measures								
Weedy Check	5.75	17.76	0.80	32.73	0.54	7.88	7.84	70.28
Weed free	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pendimethalin 1.0 kg ha^{-1} PE	1.67	4.90	0.26	9.64	0.17	2.19	2.52	23.39
Quizalofop-ethyl 60 g ha^{-1} at 25 DAS	5.66	17.65	0.79	32.08	0.53	7.72	7.45	64.90
Pendi. (750 g ha^{-1}) PE + Q.E. (45 g ha^{-1}) at 25 DAS	2.67	8.14	0.39	14.07	0.25	3.33	3.71	32.06
SEm±	0.09	0.31	0.02	0.53	0.01	0.12	0.12	0.78
CD (P=0.05)	0.25	0.87	0.05	1.50	0.03	0.34	0.34	2.18

Table 3: Effect of integrated nutrient management and weed control measures on yield, N, P and K content in mustard (pooled data of 2 years)

	Yield (Kg ha^{-1})		Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)	
	Seed	Straw	Seed	Straw	Seed	Straw	25 DAS	At harvest
Integrated nutrient management								
Control	1117	2388	2.76	0.484	0.507	0.254	0.505	1.136
100% of RDF	1641	3531	3.05	0.534	0.560	0.280	0.552	1.207
5 t FYM +75% of RDF	1586	3389	3.04	0.530	0.558	0.278	0.549	1.197
5 t FYM +100% of RDF	1767	3867	3.12	0.539	0.568	0.288	0.560	1.220
5 t FYM+50% of RDF+ biofertilizer	1545	3308	3.01	0.528	0.554	0.276	0.545	1.194
5 t FYM+75% of RDF+ biofertilizer	1735	3752	3.09	0.537	0.564	0.283	0.557	1.212
SEm±	25	69	0.04	0.004	0.006	0.004	0.006	0.010
CD (P=0.05)	75	203	0.10	0.012	0.018	0.012	0.017	0.029
Weed control measures								
Weedy Check	1350	2854	2.97	0.520	0.546	0.270	0.537	1.182
Weed free	1751	3803	3.06	0.531	0.559	0.282	0.551	1.209
Pendimethalin 1.0 kg ha^{-1} PE	1710	3687	3.04	0.528	0.556	0.280	0.548	1.204
Quizalofop-ethyl 60 g ha^{-1} at 25 DAS	1357	2926	2.99	0.523	0.548	0.273	0.541	1.185
Pendi. (750 g ha^{-1}) PE + Q.E. (45 g ha^{-1}) at 25 DAS	1658	3593	3.01	0.526	0.551	0.276	0.546	1.192
SEm±	24	54	0.03	0.004	0.005	0.003	0.005	0.010
CD (P=0.05)	66	152	NS	NS	NS	NS	NS	NS

Table 4: Residual effect of integrated nutrient management and weed control measures on fodder pearl millet (pooled data 2 years)

Treatments	Green fodder yield (tha^{1})	Dry fodder yield (tha^{1})	Nitrogen content (%)	Phosphorus content (%)	Potassium content (%)
Integrated nutrient management					
Control	13.4	2.01	1.05	0.184	0.714
100% of RDF	14.9	2.25	1.06	0.185	0.716
5 t FYM +75% of RDF	16.7	2.54	1.08	0.188	0.723
5 t FYM +100% of RDF	17.7	2.71	1.09	0.191	0.727
5 t FYM+50% of RDF+ Biofertilizer	16.2	2.47	1.07	0.187	0.722
5 t FYM+75% of RDF+ Biofertilizer	16.9	2.55	1.09	0.189	0.725
SEm±	0.4	0.06	0.01	0.002	0.006
CD (P=0.05)	1.1	0.18	NS	NS	NS
Weed management measures					
Weedy Check	16.1	2.48	1.08	0.187	0.723
Weed free	16.2	2.48	1.07	0.188	0.724
Pendimethalin 1.0 kg ha^{-1} P.E.	15.5	2.32	1.08	0.187	0.722
Quizalofop-ethyl. 60 gha^{-1} at 25 DAS	16.1	2.47	1.07	0.187	0.717
Pendi. (0.75 kg ha^{-1}) PE+ Q.E. (45 g ha^{-1}) at 25 DAS	15.8	2.37	1.06	0.188	0.721
SEm±	0.4	0.06	0.01	0.002	0.006
CD (P=0.05)	NS	NS	NS	NS	NS

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