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Study of integrated nutrient management and weed control measures on mustard (*Brassica juncea* L.) and its residual effect on fodder pearlmillet (*Pennisetum glaucum* L) in North Western Rajasthan

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Abstract
An experiment were conducted during the winter season 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 pearlmillet (*Pennisetum glaucum* L). The highest values of different weeds, yield parameters like number of silique and seeds per siliqua which laid to the highest seed yield under the treatment 5t FYM + 100% RDF and 5 t FYM + 75% RDF + biofertilizer. Among the weed management sources application of 1 kg ha^{-1} pendimethalin reduced the weeds and enhance the yield attributes and also produced the maximum seed yield. The uptake of nitrogen, phosphorous and potassium also maximum under the treatment 5 t FYM + 100% RDF and 5 t FYM + 75% RDF + biofertilizer treatments. In residual study the green and dry fodder yield were significantly highest under all INM treatments over control and 100% RDF treatment applied in preceding mustard. All INM treatments enhance the uptake of nitrogen, phosphorous and potassium over control and 100% RDF. On the basis of net returns an application of 5 t FYM + 100% RDF and 5 t FYM + 75% RDF + biofertilizer were found superior to all the treatments.

Keywords: INM, biofertilizer, FYM, weed control, mustard, fodder pearlmillet

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 for human consumption throughout northern and western India. Due to the gap between domestic availability and actual consumption of edible oils, India has to resort to import of edible oils. To increase the productivity of mustard in arid region, some constraints of low productivity like nutrient and weed management may be taken.

Mustard responds well to nitrogen and phosphatic fertilization depending upon initial soil fertility status and moisture availability during the crop season. In western Rajasthan, mustard area is expanding due to the availability of irrigation water from the Indira Gandhi Canal System. Working out balance fertilizer schedule through integrated approach of organic and inorganic can be an effective measure in boosting average yield of mustard in this region (Kumawat *et al.* 2014) [9]. In integrated nutrient management approach biofertilizer can play an important role. In intensive crop cultivation require higher use of chemical fertilizer which are costly input. Besides increased use of chemical fertilizer leads to increasing pollution. Hence, there is a strong needs of substitution for chemical fertilizer especially nitrogen and phosphorous. Azotobactor and phosphorous solublising bacteria (PSB) can help in reducing the requirement of chemical fertilizer.

Competition by weeds at initial stages is a major limiting factor to its productivity. Manual weeding at 3-4 weeks after sowing is the most common practice to control weeds in Indian mustard. But increasing wages and scarcity of labour compel to search for other alternatives and the important alternative to manual weeding seems to be herbicidal weed control. Pre-emergence herbicides are mainly used in mustard to control weeds, however not all weeds are controlled effectively by these herbicides and left over weeds pose more serious problem to the crop during grand growth period. So there is a need to explore the possibility of using post emergence herbicides in mustard. Farmers and extension functionaries are emphasizing for post-emergence herbicidal weed control due to one or other reason.

Farmers in North-western Rajasthan rear livestock for their livelihood support. Green fodder shortage particularly in summer months is most common. Except Pearlmillet, no other fodder is grown because of high temperatures. As organic matter, added in soil is get oxidized very fast due to high temperature, it is very difficult to save residual nutrients up to *kharif* season. It was therefore, thought logical to study the possibility of raising fodder pearlmillet on residual nutrients supplied to mustard. Some workers reported residual effect of herbicide applied in mustard on succeeding pearlmillet in *summer* season. Keeping all these points in view an experiment on Study of integrated nutrient management and weed control measures on mustard (*Brassica juncea* L.) and its residual effect on fodder pearlmillet (*Pennisetum glaucum* L) in North Western Rajasthan was conducted.

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 pearlmillet 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.

Number of silique of five randomly selected plants was counted and their mean was computed to express as number of silique $plant^{-1}$. Ten silique of mustard were randomly selected at harvesting. The seeds $siliqua^{-1}$ counted of ten silique from each plot and it's computed and express as number seeds $siliqua^{-1}$. 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 ^oC 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 pearlmillet 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 pearlmillet.

Results and Discussion

Effects on weeds

Integrated nutrient management

The experiment field was infested with *Chenopodium album, Chenopodium murale, Rumex dentatus, Asphodelus tenuifolius 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, Asphodelus tenuifolius, Melilotus indica* and total weeds at harvest was obtained under the treatment of 5 t FYM + 100% RDF which was statically at par with all INM treatments over control and 100% RDF. 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 Aggarwal and Ram (2011) [1] and Kumar *et al*. (2011) [8].

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}. 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. All the herbicidal treatments failed to control *Asphodelus tenuifolius* during both the years & pooled basis, hence treatments involved quizalofop-ethyl alone or in combination with pendimethalin had poor weed control under total density of weeds (Table 1) in the present study.

Effect on yield attributes and yield

Integrated nutrient management

The yield components, viz., silique $plant^{-1}$ and seeds $siliqua^{-1}$ were significantly influenced due to integrated nutrient management treatments over control (Table 2). Crop receiving 5 t FYM + 100% RDF enhance maximum number of silique $plant^{-1}$, though remained at par with that of 5 t FYM + 75% RDF + biofertilizer. On pooled data the number of seeds $siliqua^{-1}$ increased over control which might be due to synthesis of more food material resulting in higher grain production and it was also supported by Mandal and Sinha (2004) [10], Tripathi *et al.* (2010) Singh and Pal (2011) [14]. Mustard seed, straw and biological yields were significantly higher with the application of different nutrient management sources than control (Table 2) The maximum and significantly higher seed, straw and biological 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 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 viz., number of siliqua $plant^{-1}$ and seeds $siliqua^{-1}$. The yield advantage of integration of organic sources with inorganic fertilizers and also biofertilizer form associative symbiosis with plants.

Weed control measures

Maximum silique $plant^{-1}$, seed 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. However, different weed control treatments did not exhibit their significant impact on seeds per silique. The lowest yield attributes and yield was recorded under weedy check and quizalofop-ethyl 60 g ha^{-1}. The lowest value of yield attributes and 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. The poor yield attributes and yield under quizalofop-ethyl 60 g ha^{-1} was due to the poor control of broad leaved weeds like *Chenopodium album, Chenopodium murale, Rumex dentatus, Asphodelus tenuifolius* and *Melilotus indica.* The higher seed yield obtained with either of these treatments could be better explained by their effectiveness in weed control in comparison to weedy check and quizalofop-ethyl 60 g ha^{-1}. These superior treatments kept the crop almost weed free of weeds upto 30-35 DAS which in turn resulted to significant reduction in competition for nutrients and other growth resources by weeds as a consequence of which reduction in weed dry matter and less competition. The weed control measures significantly affect the straw yield of mustard which was higher in 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 g ha^{-1} POE and weedy check treatment. Reduced crop-weed competition under these treatments thus saved a substantial amount of nutrients for crop that led to profuse growth enabling the crop to utilize more soil moisture and nutrients from deeper soil layers.

Nutrient content and uptake

Integrated nutrient management

Significantly higher values of N, P and K uptakes in seed and straw as well as their total uptake were registered all nutrient management treatments over control. Application of 5 t FYM + 100% RDF registered significantly highest uptake of N, P and K in both seed and straw of mustard and found on at par with 5 t FYM + 75% RDF + biofertilizer (Table 3). The treatment 5 t FYM + 100% RDF increased total uptake of N, P and K 78.4, 79.4 and 73.6 percent over control, respectively. The increased availability of these nutrients in root zone coupled with increased metabolic activity at cellular level might increase nutrient uptake and their accumulation in vegetative plant parts. Increased uptake of N, P and K seems to be due to the fact that uptake of nutrient is a product of biomass accumulated by particular part and its nutrient content. Thus, positive impact of FYM application on both these aspects ultimately led to higher accumulation of nutrients. These results are in line with the finding of Chaurasia *et al*. (2009) [4] and Singh *et al.* (2011) [14].

Weed control measures

The weed control treatment pendimethalin 1.0 kg ha^{-1} and pendimethalin (750 g ha^{-1}) + quizalofop-ethyl (45 g ha-1) POE, significantly enhancement in total uptake of N, P and K in comparison to weedy check. N, P and K uptake under weed free was statically at par with pendimethalin 1.0 kg ha^{-1} P.E. (76.81 N, 19.94 P and 53.94 K, kg ha^{-1}). The superiority of the treatments stated above might be ascribed to the fact that these treatments controlled and suppressed the weed growth very effectively and provided weed free environment to the crop for longer time to utilize the available and applied nutrients under reduced crop-weed competition (Kour *et.al* 2014) [7].

Residual effect

Integrated nutrient management

The INM treatment applied in mustard have significant residual effect on the yield of succeeding fodder pearlmillet in *summer* season. The treatment 5 t FYM + 100% RDF significantly produced highest green and dry fodder yield which was stastically at par with all other INM treatments except 5 t FYM + 50% RDF + biofertilizer. 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 (Yadav *et al*. 2003) [17]. The N, P and K uptake were significant higher under all the INM treatments applied to mustard over control. 5 t FYM + 100% RDF significantly recorded highest N, P and K uptake by fodder which was at par with all INM treatments except 5 t FYM + 50% RDF + biofertilizer (Table 3). It might be due to manure increased the efficiency of added chemical fertilizer in soil and rate of humification. Humic acid in FYM might have enhanced the availability of both native and added nutrients in soil as a result of improved growth, yield attributes and yield of the crop significantly (Das *et al*. 2010) [5] and (Mitra and Mandal 2012) [11]. The weed management treatments did not brought significant variation.

Weed control measures

This was no significant variation obtained in weed control treatments applied in mustard on succeeding fodder pearlmillet in summer season (Sharma *et.al*. 2014) [7, 13].

Economics

Integrated nutrient management

On the basis of net returns it was clearly showed that highest net returns with treatment 5 t FYM + 100% RDF and 5 FYM + 75% of RDF + biofertilizer were ₹ 78618 and ₹76007, respectively of combined mustard and fodder pearlmillet. The treatment 5 t FYM +100% RDF increases the net returns by 17.5, 14, 10.7 and 65.4 percent respectively in comparisonto 5 t FYM + 50% of RDF + biofertilizer, 5 t FYM + 75% of RDF, 100% of RDF and control. But 5 t FYM + 100% RDF increased only 3.4 percent over 5 t FYM + 75% of RDF + biofertilizer. Which is obviously due to higher seed and straw yields and fodder yields obtained with these treatments.

Weed control measures

The net return of combined mustard fodder pearlmillet was recorded under pendimethalin 1.0 kg ha^{-1} (₹74593) at par with weed free (₹74731) Pendimethalin 1.0 kg ha-1 increased 3.6, 25.9 and 23.8 over Pendimethalin (750 g ha-1) PE + Q.E. (45 g ha^{-1}) POE at 25 DAS, quizalofop-ethyl 60 g ha^{-1} POE at 25 DAS, weedy check, respectively. Pendimethalin 1.0 kg ha^{-1} P.E. was superior treatments seems to be directly associated with the higher seed and straw yields and higher returns per rupee investment than poor yielding treatments. Results of the present investigation corroborate the findings of Nagar *et al.* (2009) [12] and Chaudhary *et al.* (2011) [3].

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

Treatments	*Chenopodium species*	*Rumex dentatus*	*Asphodelus tenuifolius*	*Melilotus indica*	Total weeds
Integrated nutrient management					
Control	4.57 (25.86)	2.59 (7.48)	1.70 (2.65)	1.94 (3.86)	5.86 (42.79)
100% of RDF	4.83 (28.95)	2.76 (8.66)	1.87 (3.37)	2.12 (4.73)	6.29 (49.30)
5 t FYM +75% of RDF	5.11 (32.50)	3.03 (10.58)	2.02 (4.02)	2.31 (5.75)	6.77 (57.25)
5 t FYM +100% of RDF	5.15 (33.00)	3.09 (10.97)	2.06 (4.24)	2.34 (5.90)	6.85 (58.62)
5 t FYM+50% of RDF+ Biofertilizer	5.09 (32.30)	3.00 (10.40)	2.00 (3.95)	2.29 (5.66)	6.73 (56.68)
5 t FYM+75% of RDF+ Biofertilizer	5.13 (32.73)	3.04 (10.65)	2.05 (4.19)	2.33 (5.87)	6.81 (57.91)
SEm±	0.05	0.03	0.03	0.03	0.06
CD (P=0.05)	0.15	0.10	0.08	0.08	0.17
Weed control measure					
Weedy Check	7.60 (57.44)	4.24 (17.63)	2.28 (4.73)	3.14 (9.43)	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)
Pendimethalin 1.0 kg ha^{-1} P.E.	3.98 (15.44)	2.47 (5.66)	2.26 (4.67)	1.89 (3.11)	5.70 (32.17)
Quizalofop-ethyl. 60 gha^{-1} at 25 DAS	7.48 (55.67)	4.17 (17.05)	2.26 (4.66)	3.12 (9.31)	9.54 (90.93)
Pendi. (750 g ha^{-1}) PE+ Q.E. (45 g ha^{-1}) at 25 DAS	5.13 (25.91)	3.00 (8.60)	2.25 (4.61)	2.25 (4.63)	6.87 (46.92)
SEm±	0.06	0.04	0.03	0.03	0.05
CD (P=0.05)	0.16	0.12	0.09	0.09	0.15

Table 2: Effect of integrated nutrient management and weed control measure on (no.m^{-2}), yield parameters and yields of mustard and fodder pearlmillet and net returns of combined mustard and fodder pearlmillet (pooled data of 2 years)

Treatments	Silique plant^{-1} (no.)	Seeds siliquae^{-1} (no.)	Seed yield (kg ha^{-1})	Green fodder yield (t ha^{-1})	Dry fodder yield (t ha^{-1})	₹ ha^{-1}
Integrated nutrient management						
Control	112.4	11.47	1117	13.4	2.01	47530
100% of RDF	154.3	12.48	1641	14.9	2.25	71027
5 t FYM +75% of RDF	149.3	12.33	1586	16.7	2.54	68947
5 t FYM +100% of RDF	170.8	12.55	1767	17.7	2.71	78618
5 t FYM+50% of RDF+ Biofertilizer	142.5	12.13	1545	16.2	2.47	66892
5 t FYM+75% of RDF+ Biofertilizer	161.6	12.51	1735	16.9	2.55	76007
SEm±	3.2	0.24	25	0.4	0.06	1286
CD (P=0.05)	9.3	0.72	75	1.1	0.18	3795
Weed management practices						
Weedy Check	122.0	11.84	1350	16.1	2.48	60268
Weed free	171.0	12.51	1751	16.2	2.48	74731
Pendimethalin 1.0 kg ha^{-1} P.E.	165.5	12.49	1710	15.5	2.32	74593
Quizalofop-ethyl. 60 gha^{-1} at 25 DAS	127.6	12.11	1357	16.1	2.47	59258
Pendi. (0.75 kg ha^{-1}) PE+ Q.E. (45 g ha^{-1}) at 25 DAS	156.2	12.27	1658	15.8	2.37	72001
SEm±	3.7	0.23	24	0.4	0.06	1335
CD (P=0.05)	10.3	NS	66	NS	NS	3748

Table 3: Effect of integrated nutrient management and weed control measure on nutrient uptake (kg ha^{-1}) of mustard and fodder pearlmillet (pooled data of 2 years**)**

Treatments	Nitrogen uptake			Phosphorous uptake			Potassium uptake			Nutrient uptake by fodder pearlmillet (kg ha^{-1})		
	Seed	Straw	Total	Seed	Straw	Total	Seed	Straw	Total	Nitrogen	Phosphorous	Potassium
Integrated nutrient management												
Control	31.00	11.63	42.63	5.70	6.11	11.80	5.67	27.24	32.91	21.2	3.7	14.4
100% of RDF	50.10	18.82	68.93	9.19	9.90	19.09	9.06	42.53	51.59	23.9	4.2	16.1
5 t FYM +75% of RDF	48.39	18.03	66.42	8.87	9.44	18.31	8.73	40.67	49.40	27.5	4.8	18.4
5 t FYM +100% of RDF	55.18	20.86	76.04	10.03	11.14	21.17	9.89	47.25	57.14	29.5	5.2	19.7
5 t FYM+50% of RDF+ Biofertilizer	46.65	17.52	64.18	8.55	9.14	17.69	8.42	39.55	47.97	26.3	4.6	17.8
5 t FYM+75% of RDF+ Biofertilizer	53.80	20.18	73.98	9.79	10.64	20.43	9.67	45.51	55.18	27.8	4.8	18.5
SEm±	1.11	0.42	1.36	0.16	0.26	0.37	0.17	0.97	1.08	0.08	0.1	0.5
CD (P=0.05)	3.28	1.25	4.02	0.46	0.77	1.08	0.51	2.88	3.20	0.23	0.4	1.5

Weed management practices												
Weedy Check	40.49	15.02	55.51	7.44	7.79	15.24	7.33	33.97	41.30	26.8	4.7	18.0
Weed free	53.83	20.29	74.12	9.81	10.77	20.59	9.68	46.12	55.80	26.7	4.7	18.0
Pendimethalin 1.0 kg ha^{-1} P.E.	52.35	19.56	71.91	9.54	10.40	19.94	9.42	44.52	53.94	25.1	4.3	16.7
Quizalofop-ethyl. 60 gha^{-1} at 25 DAS	40.74	15.36	56.10	7.47	8.04	15.51	7.38	34.76	42.13	26.4	4.6	17.7
Pendi. (0.75 kg ha^{-1}) PE+ Q.E. (45 gha^{-1}) at 25 DAS	50.19	18.97	69.16	9.17	9.97	19.14	9.08	42.93	52.00	25.3	4.4	17.1
SEm±	0.94	0.34	1.16	0.14	0.20	0.31	0.16	0.76	0.86	0.7	0.1	0.4
CD (P=0.05)	2.63	0.95	3.25	0.40	0.57	0.87	0.44	2.13	2.40	NS	NS	NS

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