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Effect of Mixed and Intercropping of Mustard {*Brassica juncea* (l.) Czern & Coss} with Lucerne (*Madicago sativa*) on Soil Fertility, Water Productivity and Yield of Mustard

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Abstract: An experiment was conducted on mixed and intercropping of mustard and lucerne during rabi and summer seasons of 2009-2010. The results indicated significantly and highest seed yield of mustard under the treatment T_5 (mustard at 30 cm + broadcasting of lucerne at the time of first irrigation). Significantly and highest value of LER (2.1), mustard equivalent yield (5,812 kg ha^{-1}) gross (Rs. 1,43,243) and net return (Rs. 1,13,230 ha^{-1}) and water productivity (10.8 kg ha^{-1} m^{-1}) were observed in treatment T_7 {mustard + lucerne (mixed seeds) at 45 cm + line sowing of lucerne between two rows at the time of first irrigation} followed by treatments T_2 and T_3. The soil OC was highest under treatment T_5. The sole crop and mixed and inter cropping systems exerted their significant effect on soil available nitrogen after harvest, treatment T_8 (lucerne sole at 22.5 cm and seed production after third cut) established its superiority by recording available nitrogen of 169.57 kg ha^{-1}. While, sole crop and mixed and inter cropping systems had no significant effect on available phosphorus, available potash and available sulphur, however the highest available phosphorus, available potash and available sulphur were recorded in the treatment T_8.

Key word: Intercropping, mixed cropping, mustard, lucerne, mustard equivalent yield, land equivalent ratio, water productivity.

Among the five important oilseed crops, mustard is second important oilseed crop in India. Mustard occupies 6.18 Mha area in India with a production of 7.36 Mt. In Gujarat, it is grown on about 0.29 Mha area with 0.33 Mt of total production. It is an important edible oilseed crop of arid and semi-arid regions of north Gujarat. Mustard (rabi) followed by pearl millet (kharif) is popular cropping system in this region. Summer pearl millet has higher water (400-500 mm) and fertilizer (120-60-00 NPK kg ha^{-1}) requirement. Due to erratic and irregular rainfall as well as increasing tube well irrigation, the water table is declining. Therefore, there is a need to find out an alternative crop to pearl millet during summer season which has less water and fertilizer requirements. There appears a good scope of inter/mixed cropping of lucerne (seed production) with mustard, which requires less irrigation water (200-250 mm) and fertilizer. This practice has more advantages over sole crop of mustard due to the maximum utilization of natural resources like sunlight, moisture, soil and saving of irrigation water, improvement of soil fertility and high economic return per unit area (Patel *et al.,* 2007). At present, there is a lack of information available on inter/mixed crop of lucerne (seed production) with mustard.The present investigation was therefore, conducted to find out suitable ratio for inter/mixed cropping of lucerne with mustard and their economic potential in this region.

Materials and Methods

An experiment was conducted during 2009-10 at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. The soil at the experimental site was loamy sand low in available nitrogen (165.25 kg ha^{-1}), medium in available phosphorus (42.6 kg ha^{-1}), high in available potassium (284.7 kg ha^{-1}) and low in sulphur (9.6 ppm). The experiment was laid out in randomized block design with four replications with ten treatments as given in Table 1. The gross and net plot size were 6.0 m x 3.6 m and 5.0 m x 1.8 m, respectively. The mustard (var. GM 3) was sown in the last week of October and lucerne (var. Anand 2)

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was sown (except mustard + lucerne mixed in line sowing) in the first fortnight of November. The summer pearl millet variety GHB 558 was sown in the second fortnight of February. The mustard and pearl millet crops were fertilized with 75:50:40 NPS and 120:60:00 NPK kg ha^{-1} in the form of DAP, urea and gypsum, respectively. The mustard crop was harvested in the second fortnight of February. Soon after lucerne was given third cut and left for seed production. The lucerne crop was fertilized with 20 kg N ha^{-1} in the form of urea after irrigation immediately after cutting. Initial soil samples were drawn from 0-15 cm soil depth before sowing of the experimental crops for the study. Soil samples were also drawn (0-15 cm depth) from each plot of all the replications after the harvest of crop. The soil samples were air dried, powdered and sieved through a 2 mm mesh for analysis. OC was determined following the method of Walkley and Black's method (Jackson, 1973), N by alkaline permanganate method (Jackson, 1973), soluble P_2O_5 by Olsen's method (Olsen *et al*., 1954), available K_2O by Flame photometer (Jackson, 1973) and S by Williams and Steinbergs (1959). Mustard crop was irrigated 6 times (290 mm) (including two common irrigations for germination and seeding establishment), lucerne was irrigated 5 times (250 mm) and summer pearl millet was irrigated 8 times (390 mm). The lucerne (seed) and pearl millet were harvested in the first fortnight of May. Seed yields of mustard, lucerne and summer pearl millet and fodder yield of summer pearl millet were recorded. Equivalent yield of mustard was calculated on the basis of market rate of each crop.

Results and Discussion

Soil fertility status (At the end of sequence)

Organic carbon: The sole crop and inter/mixed cropping systems had no significant effect on OC content of soil. The OC content was highest in the treatment T_5 (mustard at 30 cm + broadcasting of lucerne at the time of first irrigation), whereas OC was lowest in treatment T_{10} (mustard - summer pearl millet cropping system).

Available N, P, K and S: The sole crop and inter/mixed cropping systems significantly increased the available soil nitrogen after harvest (Table 1). The higher available nitrogen was observed in inter/mixed cropping systems. Treatment T_8 (lucerne sole at 22.5 cm and seed production after third cut) established its superiority as available soil nitrogen was 169.57 kg ha^{-1}. However, available soil nitrogen levels were comparable in treatments T_7, T_2, T_9, T_5, T_6 and T_4. The available soil phosphorus, potash and sulphur levels in soil were not significantly influenced by sole crop and inter/mixed cropping systems. Eventhough the highest available phosphorus (45.46 kg ha^{-1}), available potash (288.28 kg ha^{-1}) and available sulphur (10.78 kg ha^{-1}) were observed in the treatment T_8 (lucerne sole at 22.5 cm and seed production after third cut), whereas the lowest available phosphorus was observed in treatment T_{10}.

Yield parameters

Mustard seed yield: The different treatments had significant effect on seed yield (Table 2). Per cent increase in seed yield of mustard under treatments T_5, T_6, T_7, T_2, T_3 and T_{10} over T_1 was 9.2, 7.4, 6.3, 4.8, 3.5 and 0.1, respectively. These treatments were found to be at par to each other, but significantly superior over treatments T_4 and T_9. The seed yield of mustard was not reduced significantly due to inter/mixed cropping of lucerne, which may be due to complimentary effect of lucerne (Patel *et al.,* 2007) and may be attributed to N fixing behavior of lucerne crop. In inter/mixed cropping systems of mustard and lucerne, mustard received more solar radiation because of tall nature, whereas lucerne growing under mustard canopy suffered more in present experiment at vegetative growth period (Singh *et al.,* 1992).

Mustard equivalent yield: Different treatments had significant effect on mustard equivalent yield (Table 2). Significantly higher mustard equivalent yield (5812 kg ha^{-1}) was recorded in inter/mixed cropping treatment T_7 (mustard + lucerne mixed seeds at 45 cm spacing + line sowing of lucerne between two rows at the time of first irrigation to mustard), but it remained at par with T_2 (mustard + lucerne mixed seeds at 30 cm spacing) and T_3 (mustard + lucerne mixed seeds at 45 cm spacing). It may be due to additional advantage of yield obtained from inter/mixed crop of lucerne and higher yield of mustard with lucerne due to better complementary relationship. Nitrogen fixed by lucerne is the major factor responsible for higher production of mustard equivalent yield. These

Table 1. Effect of different treatments on soil fertility status (at the end of sequence) of mustard, lucerne and pearl millet

Treatment no.	Treatments	Nutrient status in soil after harvest				
		O.C.	N	P	K	S
		(%)		(kg ha^{-1})		(ppm)
Initial		0.22	165.25	42.60	284.70	9.6
T_1	Mustard sole at 45 cm spacing	0.21	147.13	40.07	281.63	9.60
T_2	Mustard + lucerne (mixed seeds) at 30 cm spacing	0.23	168.60	43.83	286.12	10.46
T_3	Mustard + lucerne (mixed seeds) at 45 cm spacing	0.23	168.56	43.67	284.59	10.27
T_4	Mustard at 45 cm and line sowing of lucerne between two rows at the time of first irrigation at 21 DAS	0.22	163.23	41.48	284.12	10.12
T_5	Mustard at 30 cm + broadcasting of lucerne at the time of first irrigation	0.24	163.53	41.74	282.77	9.69
T_6	Mustard at 45 cm + broadcasting of lucerne at the time of first irrigation	0.22	163.37	41.81	282.98	9.98
T_7	Mustard + Lucerne (mixed seeds) at 45 cm + line sowing of lucerne between two rows at the time of first irrigation	0.22	169.00	44.70	286.85	10.49
T_8	Lucerne sole at 22.5 cm and seed production after third cut	0.24	169.57	45.46	288.28	10.78
T_9	Broadcasting of mustard + lucerne (mixed seeds)	0.22	167.23	42.37	284.53	10.16
T_{10}	Mustard - summer pearl millet cropping system	0.20	143.75	39.01	280.24	9.28
S. Em. ±		0.02	5.88	2.73	11.5	0.55
C.D. (0.05)		NS	17.06	NS	NS	NS
C.V. (%)		16.63	7.24	12.87	8.1	10.90

findings are similar to the results reported by Sinsinwar *et al.* (2004) and Patel *et al.* (2007).

Other parameters

Water productivity: Mustard-summer pearl millet (T_{10}) required higher number of irrigations needing more irrigation water than mustard + lucerne mixed seeds at 45 cm spacing + line sowing of lucerne between two rows at the time of first irrigation to mustard (T_7). Mustard + lucerne mixed seeds at 45 cm spacing + line sowing of lucerne between two rows at the time of first irrigation required 540 mm irrigation water resulting in higher water productivity (10.76 kg ha^{-1} mm^{-1}) than sole mustard, mustard-summer pearl millet and other practices of mustard + lucerne. It may be due to higher equivalent yield recorded under mustard + lucerne mixed seeds at 45 cm spacing + line sowing of lucerne between two rows at the time of first irrigation than other treatments and required less water as compared to mustard - summer pearl millet. Similar results were reported by Patel *et al.* (2007).

Land equivalent ratio (LER): All inter/mixed cropping treatments recorded more than 1.00 LER values as compared to sole crops of mustard and lucerne, which ultimately indicated greater biological efficiency of the systems. Significantly higher value of LER was registered in treatment T_7, which was at par with treatments T_{10}, T_2 and T_3 having the LER value of 2.0, 2.0 and 1.9, respectively. This might be due to better land utilization and biological efficiency in inter/mixed cropping systems than sole cropping of mustard or lucerne. These findings are similar to those reported by Tiwari *et al.* (1992).

Economics: Treatment T_7 registered significantly highest gross and net returns, but it was at par with treatments T_2 and T_3. Mustard sole (T_1) recorded the lowest gross and net returns. The higher net returns under treatment T_7 may be due to more total produce and higher support price of lucerne and lower cost of production of lucerne seeds as compared to summer pearl millet, respectively. The inter/mixed cropping of lucerne with mustard

Table 2. Effect of different inter/mixed cropping systems on mustard, lucerne and pearl millet seed and fodder yield, mustard equivalent yield, land equivalent ratio, gross return, net return, BCR and water productivity

Treatments	Mustard seed yield (kg ha^{-1})	Lucerne/pearl millet yield kg ha^{-1}		Mustard equivalent yield (kg ha^{-1})	Land equivalent ratio	Net return (Rs. ha^{-1})	Water applied (mm)	Water productivity kg ha^{-1}-mm^{-1}
		Seed	Fodder					
T_1	1838	-	-	1931	1.0	30089	290	6.7
T_2	1926	521	2548	5607	2.0	107363	540	10.4
T_3	1903	509	2516	5496	1.9	104700	540	10.2
T_4	1718	378	1872	4407	1.6	76516	540	8.2
T_5	2007	376	1863	4700	1.8	83541	540	8.7
T_6	1974	385	1905	4718	1.8	83963	540	8.7
T_7	1954	572	2711	5812	2.1	113230	540	10.8
T_8	-	581	2752	4563	1.0	69446	840	5.4
T_9	1572	472	2341	4905	1.7	90514	540	9.1
T_{10}	1840	3674	9478	4810	2.0	84768	680	7.1
S.Em. ±	88	21	-	169	0.1	4536	-	-
C.D. (0.05)	258	63	-	489	0.2	13162	-	-
C.V. (%)	9.5	9.0	-	7.2	7.4	10.8	-	-

Sale price (Rs. kg^{-1}): Mustard = Rs. 24 per kg, Lucerne = Rs. 150 per kg, Lucerne fodder = Rs. 1 per kg, Pearl millet = Rs. 10 per kg and pearl millet fodder = Rs. 3 per kg, Irrigation charge: Rs. 1000 irrigation^{-1} ha^{-1}

gave an extra income of Rs. 83,141 and Rs. 28,462 per ha over the sole crop of mustard and mustard-summer pearl millet sequence, respectively. These confirm the finding of Patel *et al.* (2007). This results clearly indicated that growing of lucerne in mustard as inter/ mixed cropping systems is beneficial leading to highest monetary returns. Similar results were reported by Patel *et al.* (2007).

It is concluded that inter/mixed cropping of mustard+lucerne mixed seeds at 45 cm spacing+line sowing of lucerne between two rows at the time of first irrigation is the remunerative over rest of the treatments and preferred over sole mustard and lucerne crops.

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