JOURNAL OF PURE AND APPLIED MICROBIOLOGY, Dec. 2016. Vol. **10**(4), p. 2827-2833

Effect of Row Arrangements on Quality and Nutrient Dynamics of Linseed (*Linum usitatissimum l.*) + Dwarf Field Pea (*Pisum sativum l.*) Intercropping Association in Irrigated Condition

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http://dx.doi.org/10.22207/JPAM.10.4.43

(Received: 17 July 2016; accepted: 21 September 2016)

Field experiments were conducted during winter season 2013-14 to study the effect of various row arrangements on quality and nutrient dynamics of linseed + dwarf field pea were investigated. The highest grain and straw yield, protein and oil content were recorded in T_8 followed by T_9 whereas highest protein and NKP content were recorded in T_{11} followed by T_5. In case of dwarf field pea highest grain, straw and protein yield was recorded in T_{11} followed by T_5 whereas highest protein and NPK content were recorded in T_8. None of the row arrangement was show superiority over sole crop of either linseed or field pea.

Keywords: Intercropping, Protein, Nutrient dynamics, Linseed, Dwarf field pea.

Linseed or flaxseed (*Linum usitatissimum* L.) is an herbaceous plant belonging to Linaceae family, is an important industrial crop grown worldwide for its fibre and oilseed Buranov *et al*. 2010. Linseed has been used for a very long time in human and animal nutrition. Currently, there is an increasing interest in linseed oil because of its oil is highly rich in polyunsaturated fatty acids (PUFA) and contains more than 50% of a-linolenic acid (ALA), which is an omega-3 and essential fatty acid (FA). Consumption of omega-3 FA is necessary for many physiological reasons and has been associated with a lower incidence of many types of illnesses among which inflammatory and cardiovascular diseases Simopoulos, 2002. Among the oilseed crops grown during *rabi* season, is next in importance to rapeseed and mustard in area and production both. One of the reasons of the linseed finding place in mixed or intercropping has been minimizing risk of moisture variation and infestation of insect pest and diseases Sharma *et al*. 2012.

Pulses are the primary source of protein and fibre in human diet and also maintain the soil fertility through biological nitrogen fixation in soil and thus play a vital role in maintaining soil fertility. India is the largest producer and consumer of pulses in the world. India produces 17.21 million tonnes of pulses from an area of 24.78 million hectares. The average productivity of country is about 689 kg ha^{-1} against the global productivity of 857 kg ha^{-1} Singh *et al*. 2009. Field pea (*Pisum sativum* L. 2n = 14, Fabaceae) is one of the most important *rabi* season food legume crops in the

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world covering 6.59 million hectares FAOSTAT, 2012 and is the third most widely grown grain legume worldwide Tyagi *et al*. 2012. In India, fieldpea is an important *rabi* pulse crop grown in about 0.76 m ha area with annual production of 0.71 m tones and productivity of 993 kg ha^{-1} PC Report, 2012. Uttar Pradesh and Madhya Pradesh are the leading fieldpea growing state contributing 49% of country's production. Besides these states, Bihar, Assam, Maharashtra and Orissa are also fieldpea growing states. Unfortunately, the overall yield of fieldpea is low in India as compared to the world average yield due to the narrow genetic base and limited variability used in the development of local varieties. Grains of pea are rich source of proteins, carbohydrates, minerals and vitamins, which are good for human and livestock consumption. Dry pea grains are naturally dried ones that are consumed in soups, stews and various other Cuisines Parihar *et al*. 2014.

Growing of two or more generally dissimilar crops simultaneously on the same piece of land, in distinct row arrangement is known as intercropping. It is a practice that increases diversity in the cropping system Bahadur *et al*. 2015. Plant population and spatial arrangement in intercropping have important effects on the balance of competition between component crops and their productivity Tripathi *et al.* 2010. It also ensures adequate yield of one of the crops under aberrant weather conditions Rao and Willey, 1980. Biological efficiency of any intercropping systems depends on the identification of compatible genotypes, spatial arrangement, fertility and water management. Information on linseed + dwarf field pea intercropping system is inadequate. Keeping this in view, present investigation was undertaken to evaluate the quality and nutrient removal asinfluenced by different row arrangements of both crops.

MATERIALS AND METHOD

The field experiment was conducted during the *rabi* season of 2013-14 at Agricultural research farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh. This is geographically located 25°18 N latitude and 83°3 E, longitude at an elevation of about 128.39 m above mean sea level in the northern Gangatic Alluvial plains. The experimental site was fairly uniform in topography and well drained. It has sub-tropical type of climate with hot summer and cold winter. The total rainfall in the study area during the crop growing season (5^{th} November to 1^{st} April) was recorded 133.9 mm, besides the crop was irrigated two time (pre-sowing and pre flowering). The irrigation was given 5 cm each time. Prior to the commencement of the present study, the field was under rice-intercropping {(linseed + dwarf field pea) with similar set of treatments)}. The Physico-chemical analysis of the soil was done by collecting soil samples from a depth of 0-30 cm. Soil at the experimental field was sandy clay loam in texture with neutral in reaction (pH 7.22), EC (0.28 dS m^{-1}), bulk density (1.39 g cm^{-3}), low in organic carbon (0.45%), available N (209 kg ha^{-1}), P (19.7 kg ha^{-1}) and medium in K (215.9 kg ha^{-1}). The experiment was conducted in randomized block design, with fourteen row arrangement treatment, *viz*. sole linseed (T_1), sole dwarf field pea (T_2), row ratio of 3:1 with 75% linseed + 25% dwarf pea (T_3), row ratio of 3:2 with 60% linseed + 40 dwarf field pea (T_4), row ratio of 1:3 with 25% linseed + 75% dwarf field pea (T_5), row ratio of 2:3 with 40% linseed + 60% dwarf field pea (T_6), row ratio of 3:3 with 50% linseed + 50% dwarf field pea (T_7), row ratio of 4:1 with 80% linseed + 20% dwarf field pea (T_8), row ratio of 4:2 with 66.67% linseed + 33.34% dwarf field pea (T_9), row ratio of 4:3 with 57.15% linseed + 42.86% dwarf field pea (T_{10}), row ratio of 1:4 with 20% linseed + 80% dwarf field pea (T_{11}), row ratio of 2:4 with 33.34% linseed + 66.67% dwarf field pea (T_{12}), row ratio of 3:4 with 42.86% linseed + 57.15% dwarf field pea (T_{13}) and row ratio of 4:4 with 50% linseed + 50% dwarf field pea (T_{14}). The gross plot size was 5.0 m × 4.0 m. The seed rate of crop were using 30 kg ha^{-1} of linseed and 80 kg ha^{-1} of dwarf field pea in lines spaced as per treatment in sole cropping. In intercropping treatments row to row distance was maintained 30 cm and sowing was done by *"kera"* method in open furrow. The crop was sown on 15 November 2013 with using "Shekhar" linseed and "Prakash" dwarf field pea variety. The recommended fertilizer dose for linseed 50 kg N, 40 kg P_2O_5 and 40 kg K_2O and 20 kg N, 40 kg P_2O_5 and 40 kg K_2O for dwarf field pea were applied through urea DAP and MOP at prior to sowing only in sole crop. In intercropping combinations seed rate and fertilizers were adjusted

Table 1. Oil content, oil yield, protein content and protein yield of linseed and dwarf field pea

Treatments	Linseed						Dwarf field pea			
	Grain yield (kg^{-1})	Straw yield (kg^{-1})	Oil content (%)	Oil Yield ($kg\ ha^{-1}$)	Protein content (%)	Protein yield ($kg\ ha^{-1}$)	Grain yield (kg^{-1})	Straw yield (kg^{-1})	Protein content (%)	Protein yield ($kg\ ha^{-1}$)
T_1 (Sole linseed)	1640	3630	41.08	673.8	20.2	332.5	-	-	-	-
T_2 (sole dwarf field pea)	-	-	-	-	-	-	1775	2769	21.0	372.8
T_3 (3:1)	1301	2770	40.96	533.2	20.5	267.1	440	629	22.8	98.8
T_4 (3:2)	1118	2321	40.81	456.4	20.7	231.8	565	822	22.6	127.8
T_5 (1:3)	583	1120	39.75	232.0	21.6	126.3	1294	2001	21.3	275.8
T_6 (2:3)	740	1541	39.85	294.9	21.0	155.4	1025	1577	21.5	220.3
T_7 (3:3)	841	1760	39.92	335.9	21.1	177.2	995	1494	21.7	216.1
T_8 (4:1)	1438	3070	40.98	589.4	20.6	296.2	397	562	22.9	91.1
T_9 (4:2)	1152	2450	40.83	470.5	20.3	232.8	661	952	22.7	150.0
T_{10} (4:3)	916	1930	40.73	373.4	20.6	188.5	791	1161	22.4	177.4
T_{11} (1:4)	341	650	39.66	135.5	21.8	74.4	1426	2214	21.3	303.0
T_{12} (2:4)	510	1025	39.69	202.4	21.4	109.0	1167	1792	21.4	250.2
T_{13} (3:4)	695	1370	39.85	277.0	21.2	147.4	1029	1560	21.7	223.1
T_{14} (4:4)	934	1880	40.11	374.9	20.7	193.7	679	1005	21.5	148.6
CD at 5%	65.41	78	0.119	26.48	0.455	15.46	27	94.8	1.30	15.4

Table 2. Nitrogen, Phosphorus and Potassium content in grain and straw of linseed and dwarf field pea

Treatments	Linseed						Dwarf field pea					
	Nitrogen (%)		Phosphorous (%)		Potassium (%)		Nitrogen (%)		Phosphorous (%)		Potassium (%)	
	Grain	straw	Grain	straw	Grain	Straw	Grain	straw	Grain	straw	Grain	Straw
T_1 (Sole linseed)	3.23	0.577	0.777	0.213	3.04	0.890	-	-	-	-	-	-
T_2 (sole dwarf field pea)	-	-	-	-	-	-	3.36	1.21	1.15	0.421	0.667	1.11
T_3 (3:1)	3.28	0.583	0.779	0.214	3.09	0.892	3.63	1.41	1.28	0.531	0.763	1.24
T_4 (3:2)	3.32	0.587	0.782	0.216	3.12	0.894	3.60	1.38	1.27	0.530	0.747	1.23
T_5 (1:3)	3.46	0.614	0.789	0.228	3.21	0.908	3.41	1.25	1.17	0.451	0.682	1.10
T_6 (2:3)	3.36	0.605	0.785	0.225	3.16	0.905	3.44	1.28	1.21	0.461	0.687	1.12
T_7 (3:3)	3.37	0.597	0.782	0.222	3.14	0.902	3.48	1.34	1.23	0.460	0.699	1.13
T_8 (4:1)	3.29	0.585	0.779	0.215	3.08	0.894	3.67	1.43	1.30	0.539	0.768	1.25
T_9 (4:2)	3.24	0.593	0.780	0.219	3.11	0.896	3.62	1.40	1.28	0.531	0.763	1.23
T_{10} (4:3)	3.29	0.605	0.783	0.222	3.11	0.903	3.59	1.36	1.24	0.529	0.750	1.21
T_{11} (1:4)	3.48	0.616	0.793	0.230	3.25	0.911	3.40	1.24	1.16	0.447	0.672	1.12
5T_{12} (2:4)	3.42	0.610	0.789	0.227	3.22	0.907	3.43	1.27	1.20	0.469	0.685	1.13
T_{13} (3:4)	3.39	0.591	0.785	0.225	3.16	0.902	3.47	1.31	1.23	0.472	0.691	1.14
T_{14} (4:4)	3.32	0.597	0.781	0.225	3.12	0.903	3.49	1.35	1.23	0.483	0.716	1.15
CD at 5%	0.073	0.010	0.004	0.004	0.080	0.005	0.170	0.064	0.052	0.010	0.023	0.076

Table 3. Uptake of Nitrogen, Phosphorus and potassium by grain and straw of linseed

Treatments	Linseed						Dwarf field pea					
	Nitrogen uptake (kg ha^{-1})		Phosphorus uptake (kg ha^{-1})		Potassium uptake (kg ha^{-1})		Nitrogen uptake (kg ha^{-1})		Phosphorus uptake (kg ha^{-1})		Potassium uptake (kg ha^{-1})	
	Grain	straw	Grain	straw	Grain	Straw	Grain	straw	Grain	straw	Grain	Straw
T_1 (Sole linseed)	53.2	20.9	12.7	7.7	49.9	32.3	-	-	-	-	-	-
T_2 (sole dwarf field pea)	-	-	-	-	-	-	59.7	33.5	20.5	11.7	11.8	30.7
T_3 (3:1)	42.7	16.1	10.1	5.9	40.2	24.7	15.8	8.8	5.6	3.3	3.3	7.8
T_4 (3:2)	37.1	13.6	8.7	5.0	34.9	20.8	20.4	11.3	7.2	4.1	4.2	10.1
T_5 (1:3)	20.2	6.9	4.6	2.6	18.8	10.2	44.1	24.9	15.2	9.0	8.8	22.0
T_6 (2:3)	24.9	9.3	5.8	3.5	23.4	14.0	35.2	20.3	12.4	7.3	7.0	17.7
T_7 (3:3)	28.4	10.5	6.6	3.9	26.4	15.9	34.6	20.0	12.3	6.9	7.0	16.9
T_8 (4:1)	47.4	18.0	11.2	6.6	44.4	27.5	14.6	8.0	5.2	3.0	3.1	7.0
T_9 (4:2)	37.3	14.5	9.0	5.4	35.8	21.9	24.0	13.4	8.5	5.0	5.0	11.7
T_{10} (4:3)	30.2	11.7	7.2	4.3	28.5	17.4	28.4	15.7	9.7	5.8	5.9	14.0
T_{11} (1:4)	11.9	4.0	2.7	1.5	11.1	5.9	48.5	27.5	16.5	9.8	9.6	24.7
T_{12} (2:4)	17.4	6.2	4.0	2.3	16.4	9.3	40.0	22.8	14.0	8.3	8.0	20.3
T_{13} (3:4)	23.6	8.1	5.5	3.1	21.9	12.4	35.7	20.5	12.7	7.4	7.1	17.8
T_{14} (4:4)	31.0	11.2	7.3	4.2	29.2	17.0	23.8	13.5	8.4	4.9	4.9	11.6
CD at 5%	2.47	0.52	0.52	0.18	2.18	0.727	2.48	1.31	0.72	0.44	0.26	1.32

according to number of row arrangement.

RESULTS AND DISCUSSION

Protein content and protein yield

Table 1 indicated that intercropping treatments significantly influenced the protein content in both crops linseed and dwarf field pea. The protein in linseed grain increased from 20.2 to 21.8% with various treatments. The highest protein content and protein yield was recorded under row ratio of 1:4 with 20% linseed + 80% dwarf field pea (T_{11}) and sole linseed (T_1) respectively. Where at par protein content was recorded with row ratio of 1:3 with 25% linseed + 75% dwarf field pea (T_5) and row ratio of 2:4 with 33.34% linseed + 66.67% dwarf field pea (T_{12}). The highest protein content and protein yield in dwarf field pea was recorded under row ratio of 4:1 with 80% linseed + 20% dwarf field pea (T_8) and sole dwarf field pea respectively as compared to other treatments. Where at par protein content was recorded under row ratio of 3:1 with 75% linseed + 25% dwarf pea (T_3), row ratio of 3:2 with 60% linseed + 40 dwarf field pea (T_4), row ratio of 3:3 with 50% linseed + 50% dwarf field pea (T_7), row ratio of 4:2 with 66.67% linseed + 33.34% dwarf field pea (T_9), row ratio of 3:4 with 42.86% linseed + 57.15% dwarf field pea (T_{13}) and row ratio of 4:4 with 50% linseed + 50% dwarf field pea (T_{14}). This might be due to the increase or decrease of nitrogen content in grain because protein content was directly related to nitrogen content in plant. These results are corroborated with the research finding of Singh *et al*. (2013).

Oil content and oil yield

The significantly highest oil content in linseed and oil yield was recorded under sole linseed (T_1) over the remaining treatments. Among the row arrangements, significantly highest oil content and oil yield was recorded under row ratio of 4:1 with 80% linseed + 20% dwarf field pea (T_8) over other row arrangements and oil content was statistically at par with row ratio of 3:1 with 75% linseed + 25% dwarf pea (T_3). Oil yield is a complex character determined by interaction between genetic and environmental factors and has a direct dependence on seed yield and oil content. This was mainly owing to higher seed yield and oil content in linseed. This is in agreement with the earlier findings of Kumawat *et al*. (2014).

Nutrient content

The row arrangement significantly influenced N, P and K concentration in seed and straw of linseed (Table 2). It was significantly highest with row ratio of 1:4 with 20% linseed + 80% dwarf field pea (T_{11}) and it were at par with row ratio of 1:4 with 25% linseed + 75% dwarf field pea (T_5) and row ratio of 2:4 with 33.34% linseed + 66.67% dwarf field pea **(**T_{12}**).** The row arrangements significantly influenced N, P and K concentration in seed and straw of dwarf field pea (Table 2). Row ratio of 4:1 with 80% linseed + 20% dwarf field pea (T_8) recorded significantly highest N, P and K content in seed and straw and it were at par with row ratio of 3:1 with 75% linseed + 25% dwarf pea (T_3), row ratio of 3:2 with 60% linseed + 40 dwarf field pea (T_4), row ratio of 4:2 with 66.67% linseed + 33.34% dwarf field pea (T_9) and row ratio of 4:3 with 57.15% linseed + 42.86% dwarf field pea (T_{10}). In general nutrient content were decrease with increasing dry matter production due to portioning of nutrient. These findings confirmed those obtained by Kumawat *et al*. (2014).

Nutrient uptake

The N, P and K depletion by linseed increased with increasing plant population and higher biomass production and significantly highest depletion of nutrients (N, P and K) by linseed were recorded under sole linseed (Table 3). Among the intercropping association significantly highest N, P and K depletion was recorded under row ratio of 4:1 with 80% linseed + 20% dwarf field pea (T_8). The N, P and K depletion by dwarf field pea increased with increasing plant population and higher biomass production and significantly highest depletion of nutrients (N, P and K) by dwarf field pea were recorded under sole dwarf field pea (Table 3). Among the intercropping association significantly highest N, P and K depletion was recorded under row ratio of 1:4 with 20% linseed + 80% dwarf field pea (T_{11}) due to higher dry matter production which govern the uptake. These findings are in close agreement with Rahimi *et al.* (2011).

ACKNOWLEDGEMENTS

The authors are thankful to the head department of Agronomy, Institute of Agricultural Sciences, BHU, Varanasi, for encouraging such research and providing necessary facilities for the successful completion of research work.

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