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Effect of Different Pulse and Oilseed based Cropping Systems on Yield and Nutrient Budgeting under Rainfed Conditions of Jammu

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ABSTRACT

Background: Maize-wheat is the predominant cropping system of dryland ecology of Jammu region, but due to their comparatively higher input requirements especially of nutrients and water under the fragile ecology of these dry lands an untenable threat has been posed to their factor productivities. Therefore, all cropping sequences that suit and sustain better on the natural resources of the dryland ecosystems for a longer period of time needs to be explored.

Methods: The treatments consisted of two oilseeds *i.e.* mustard) and gobhi sarson and two pulse crops *i.e.* chickpea and field pea taken during *rabi* were followed by two oilseed *i.e.* soybean and sesame and two pulse crops *i.e.* green gram and black gram grown during *kharif*. The experiment was laid out in randomized block design with four replications.

Result: Significantly higher chickpea equivalent yield of green gram was observed with field pea- green gram sequence (10.26 q/ha) which was at par with the chickpea - green gram and field pea - black gram system. The available nitrogen status was significantly influenced and recorded highest (166.82kg/ha) under field pea- green gram system. Further overall nutrient mining by this system was quite low as compared to other systems.

Key words: Available nutrients, Balance sheet, Cropping system, Equivalent yield.

INTRODUCTION

Oilseeds and pulses plays vital role in the human diet. Oilseeds and pulse crops account for about 26 per cent of the gross cropped area and contribute 20 per cent to the value of output (Rohullah *et al*., 2017). In world, pulses crop was cultivated on an area of about 80.8 mha with production and productivity of about 73 mt and 904 kg/ha (Anonymous, 2020a). The area, production and productivity of oilseed was about 188 mha, 584 mt and 1339 kg/ha in world (Anonymous, 2020b). Whereas in India, pulses and oilseeds are grown on an area of about 26.59 m ha, 26.08 m ha and with production and productivity of about 20.26 mt, 29.65 mt and 762 kg/ha,1137 kg/ha (Anonymous, 2020b). The UT of Jammu and Kashmir is deficient not only in cereals but in pulse and oilseed grains also (Rohullah *et al*., 2017). It is further added that oilseed and pulse crops occupy a unique position on dryland areas of Jammu and have better capabilities to sustain high moisture deficits as compared to cereal crops.

Maize-wheat is the predominant cropping system of dry land ecology of Jammu region, but due to their comparatively higher input requirements especially of nutrients and water under the fragile ecology of these dry lands an untenable threat has been posed to their factor productivities (Rohullah *et al*., 2017). Dry lands besides being water deficient are characterized by high evaporation rates, exceptionally high day temperature during summer, low humidity and high runoff and soil erosion. (Rohullah *et al*. 2017, Shivakumar and Ahlawat, 2018). Despite these limitations, this tract has enormous potential to contribute considerable magnitude of crop production with the substitution of crops which fits well in the existing agro-climatic ecosystem. The only hope for potential increase in production of food grains lies with dry land areas which at present can be a viable proposition for second green revolution. Hence keeping in view the above consideration, this study was planned to assess the effects of diversified rotation system as drought adaptation practices on the productivity and stability of pulses and oilseed cropping systems.

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MATERIALS AND METHODS

Field experiments were conducted during *rabi* 2014-15 to *kharif* 2016 at the Pulse Research Sub Station, Samba,

Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu. The soil of the experimental site was sandy loam in texture, low in available nitrogen (142.89 kg/ha), sulphur (7.45 ppm/ha)and medium in available phosphorus (10.72 kg/ha) and potassium (154.36 kg/ha). The treatments consisted of two oilseeds *i.e*. mustard (*Brassica juncea*) and gobhi sarson (*Brassica napus*) and two pulse crops *i.e*. chickpea (*Cicer arietinum*) and field pea (*Pisum sativum*) taken during *rabi* which were followed by two oilseed *i.e*. soybean (*Glycine max*) and sesame(*Sesamum indicum)* and two pulse crops *i.e*. green gram (*Vigna radiata*) and black gram (*Vigna mungo*) grown during *kharif*. The experiment was laid out in randomized block design with four replications. Chick pea, field pea, mustard, green gram and black gram were sown at a spacing of 30 cm × 10 cm, gobhi sarson and soybean was sown at a spacing of 45 cm × 10 cm and sesame was sown at a spacing of 30 cm × 15 cm. All the crops were sown with recommended package of practices.

Before and after harvest of crops, soil samples were taken for determination of available nitrogen (Subbiah and Asija, 1956), phosphorus (Olsen *et al.,* 1954), potassium and sulphur (Merwin and Peech, 1950). The uptake of nutrients by seeds and stover were calculated by multiplying per cent nutrient content of the individual crop with its respective dry matter of seeds and stover.

Nutrient balance

Nutrients (NPKS) balance of cropping systems was calculated from total nutrient added to the whole system and total nutrient uptake by the whole cropping sequence as well as soil available nutrients status at the end of last crop harvest.

Equivalent yield

Chickpea equivalent yield was calculated by using the following formula:

$$CEY = \frac{\Sigma.\ Yi \times Pi}{P\ (c)}$$

Where
CEY = Chickpea equivalent yield.
Yi = Yield of different crops.
Pi = Price of respective crops.
P (c) = Price of chickpea.

Statistical analysis of the data was carried out using standard analysis of variance (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Yield of different oilseed/pulse crops

Green gram and soybean crops in systems with field pea recorded highest mean seed yields (7.17 and 11.21q/ha) and yields of these crops were statistically at par with chickpea- green gram (7.00 q/ha) and chickpea -soybean systems (10.47q/ha) (Table 1 and Fig 1a, b). Black gram and sesame crops also followed the similar trends in realizing mean seed yield (6.99 and 3.87q/ha). On the other hand, stover yield also followed the same trend as seed yield. This might have happened due to fact that legumes played an important role in restoring the soil fertility in terms of N and other biological parameters which in turn improved the yield of succeeding crop. These results corroborate with findings of Shivakumar and Ahlawat (2018).

Chickpea equivalent yield

Among the different *kharif* crops, (Table 1), field pea- green gram recorded higher equivalent yield (10.26 q/ha) and was at par with the chickpea- green gram (10.03q/ha), field pea-black gram system (9.51 q/ha) and field pea-soybean system (8.77 q/ha). This was attributed to higher yield and comparatively higher market prices fetched by main product of field pea and green gram. These results also corroborate to the findings of Shivakumar and Ahlawat (2018).

Fertility status of soil

Among the different cropping system, systems(Table 1), available nitrogen in soil was significantly improved due to field pea- green gram crops (166.82 kg/ha). This might be due to the fact that pulses add substantial amount of nitrogen in soil after harvest due to atmospheric nitrogen fixation by root nodules (Singh *et al.,* 2017). Numerically available phosphorus and potassium were improved due to legume-legume system. This might be due to fact that phosphorus was utilized as a source of energy for nitrogen fixation in legume crops. These results corroborate with the findings of Sree and Sridhar (2019). The available sulphur was highest in oilseed crops as compared to pulse crops. Whereas in pulses crops slight increase in available sulphur was noticed, this is due to the fact that adequate application of phosphorus to the pulse crop increased root growth and nodulation which resulted in availability of sulphur in soil (Patel *et al.,* 2019).

Nutrient uptake

A perusal of data presented in Table 1 and Fig 2 (a, b, c and d) and Fig 3 (a, b and c) revealed that field pea- green gram recorded significantly highest uptake of nitrogen (24.21kg/ha) and phosphorus (3.71kg/ha) by seeds of *kharif* oilseed/pulse crops over rest of the green gram based systems. Black gram, sesame and soybean grown in system with chickpea, field pea, mustard and gobhi sarson followed the similar trend as in green gram, except black gram. This might be due to the reason that legume - legume system improved the physical, chemical and biological properties of soil which might have resulted in efficient translocation of nutrients towards plant system during vegetative growth. The results were in accordance with the findings of Sharma *et al.* (2000).

Nutrient budgeting

The data presented in Table 2 revealed that field pea-green gram recorded maximum recovery of available nitrogen (13.18 kg/ha) than other cropping systems. This might have happened due to good growth of legume crop resulting in higher number of nodules /plant which contributed for higher nitrogen fixation and residual nitrogen in the soil. These results are in line with the findings of Kumar *et al.* (2016). Maximum build up of phosphorus was recorded in mustard-

Table 1: Yield, CEY, Available and uptake of soil nutrients after harvest of *kharif* crop in *rabi* oilseed/pulse-*kharif* oilseed/pulse systems.

Cropping system	Seed yield (q/ha)	Stover yield (q/ha)	Chickpea equivalent yield (q/ha)	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)	Sulphur (ppm/ha)	Nitrogen uptake (kg/ha)		Phosphorus uptake (kg/ha)		Potassium uptake (kg/ha)		Sulphur uptake (kg/ha)	
				0-15 cm soil depth				Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover
	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Chickpea - green gram	7.00 (±0.39)	17.32	10.03	163.44	11.74	156.57	8.15	23.56 (±1.19)	26.48	3.54 (±0.17)	3.96	6.65	22.07	1.60	1.55
Field pea-green gram	7.17 (±0.26)	17.63	10.26	166.82	12.02	156.83	8.34	24.21 (±1.05)	26.88	3.71 (±0.03)	4.15	6.81	22.78	1.65	1.69
Mustard-green gram	6.17 (±0.18)	16.77	8.83	149.54	13.34	155.66	9.37	20.11 (±0.56)	25.70	3.17 (±0.12)	3.52	5.79	21.23	2.33	2.81
Gobhi sarson-green gram	5.93 (±0.30)	16.45	8.49	147.99	13.18	155.61	9.23	19.02 (±0.87)	25.42	3.18 (±0.21)	3.29	5.57	20.69	2.27	2.76
Chickpea-black gram	6.42	17.00	8.73	161.92	11.75	156.47	7.76	20.57 (±0.70)	25.18	3.28 (±0.03)	3.84	6.03	21.48	1.44	1.47
Field pea-black gram	6.99	17.40	9.51	166.16	11.89	156.72	8.11	22.56 (±0.79)	25.84	3.54 (±0.18)	4.12	6.53	22.09	1.64	1.65
Mustard-black gram	6.28	16.70	8.53	148.45	13.22	155.42	9.25	19.76 (±0.76)	24.44	3.25 (±0.17)	3.75	5.74	20.34	1.98	2.59
Gobhi sarson-black gram	6.12	16.32	8.32	147.38	13.08	155.30	9.06	19.25 (±1.25)	23.85	3.21 (±0.16)	3.58	5.51	20.09	1.70	2.33
Chickpea - sesame	3.69	20.98	5.19	155.36	11.36	153.80	7.28	12.37 (±0.69)	18.02	1.54 (±0.09)	4.09	1.51	12.04	0.77	1.72
Field pea-sesame	3.87	21.73	5.44	156.08	11.54	154.36	7.37	12.72 (±0.39)	18.69	1.75 (±0.08)	4.35	1.60	12.66	0.81	1.82
Mustard-sesame	3.44	20.04	4.84	143.84	11.94	149.33	7.63	10.87 (±0.37)	16.89	1.46 (±0.09)	3.81	1.37	11.77	1.01	3.11
Gobhi sarson-black gram	3.25	19.79	4.57	143.52	11.84	147.84	7.45	10.00 (±0.34)	16.87	1.41 (±0.07)	3.47	1.23	11.28	0.96	2.90
Chickpea-soybean	10.47 (±0.29)	24.12	8.19	160.97	12.49	156.67	8.34	64.22 (±3.37)	30.69	4.04 (±0.28)	5.41	10.26	24.83	2.15	2.30
Field pea-soybean	11.21 (±0.37)	24.20	8.77	163.15	12.70	156.71	8.68	69.56 (±2.86)	31.32	4.58 (±0.24)	5.60	11.05	25.19	2.60	2.42
Mustard-soybean	9.66 (±0.06)	23.90	7.56	147.17	13.11	156.56	9.55	59.00 (±0.94)	31.53	3.98 (±0.14)	5.19	9.56	24.32	2.91	3.56
Gobhi sarson-soybean	9.45 (±0.28)	23.34	7.39	146.15	12.90	156.38	9.49	57.27 (±1.72)	30.03	3.96 (±0.12)	5.05	9.18	23.56	2.75	3.43
SEm(±)	-	-	0.58	1.90	0.66	2.13	1.04	-	-	-	-	-	-	-	-
LSD *(p=0.05)*	-	-	1.78	5.41	NS	NS	NS	-	-	-	-	-	-	-	-

Values in paranthes indicates standard error mean bar.

Table 2: Balance sheet of nutrients after two cycles of different *rabi* oilseed /pulse - *kharif* oilseed / pulse systems.

Cropping system	Nutrients	Initial Status		Addition		Total Uptake		Expected balance		Actual Balance		Buildup /Depletion		Mean
		SY_1	SY_2	SY_1	SY_2	SY_1	SY_2	SY_1	SY_2	SY_1	SY_2	SY_1	SY_2	
Chickpea-green gram	N	142.89	158.51	30	30	92.35	108.5	80.54	80.01	160.68	166.2	17.79	7.69	12.74
	P	10.25	11.30	80	80	16.98	21.12	73.27	70.18	11.3	12.18	1.05	0.88	0.97
	K	154.36	155.70	0	0	48.73	55.52	105.63	100.18	155.7	157.43	1.34	1.73	1.54
	S	7.45	7.57	0	0	8.87	10.57	-1.42	-3.00	7.57	8.72	0.12	1.15	0.64
Field pea-green gram	N	142.89	164.38	30	30	119.3	131.08	53.59	63.3	164.38	169.25	21.49	4.87	13.18
	P	10.25	11.83	80	80	23.87	26.68	66.38	65.15	11.83	12.21	1.58	0.38	0.98
	K	154.36	155.86	0	0	61.16	65.34	93.2	90.52	155.86	157.79	1.5	1.93	1.71
	S	7.45	7.78	0	0	13.04	14.00	-5.59	-6.22	7.78	8.89	0.33	1.11	0.72
Mustard-green gram	N	142.89	148.04	75	75	103.83	116.08	114.06	106.96	148.04	151.03	5.15	2.99	4.07
	P	10.25	12.72	70	70	20.18	23.25	60.07	59.47	12.72	13.95	2.47	1.23	1.85
	K	154.36	154.98	15	15	82.92	92.79	86.44	77.19	154.98	156.34	0.62	1.36	0.99
	S	7.45	8.77	20	20	24.65	29.07	2.81	-0.30	8.77	9.96	1.32	1.19	1.26
Gobhi sarson-green gram	N	142.89	146.23	65	65	120.85	131.78	87.04	79.45	146.23	149.74	3.34	3.51	3.43
	P	10.25	12.47	90	90	23.20	26.48	77.05	75.99	12.47	13.88	2.22	1.41	1.82
	K	154.36	154.90	15	15	94.34	100.45	75.02	69.45	154.9	156.31	0.54	1.41	0.97
	S	7.45	8.65	20	20	29.27	32.65	-1.82	-4.00	8.65	9.81	1.20	1.16	1.18
Chickpea-black gram	N	142.89	157.72	30	30	85.92	105.91	86.97	81.81	157.72	166.12	14.83	8.40	11.62
	P	10.25	11.25	80	80	16.31	21.01	73.94	70.24	11.25	12.09	1.00	0.84	0.92
	K	154.36	155.60	0	0	46.15	55.37	108.21	100.23	155.6	157.34	1.24	1.74	1.49
	S	7.45	7.14	0	0	8.46	10.52	-1.01	-3.38	7.14	8.38	-0.31	1.24	0.47
Field pea-black gram	N	142.89	163.70	30	30	116.63	128.08	56.26	65.62	163.7	168.62	20.81	4.92	12.87
	P	10.25	11.64	80	80	23.59	26.56	66.66	65.08	11.64	12.13	1.39	0.49	0.94
	K	154.36	155.76	0	0	59.67	64.57	94.69	91.19	155.76	157.67	1.40	1.91	1.65
	S	7.45	7.74	0	0	12.90	14.04	-5.45	-6.30	7.74	8.47	0.29	0.73	0.51
Mustard-black gram	N	142.89	146.95	75	75	101.73	116.30	116.16	105.65	146.95	149.95	4.06	3.00	3.53
	P	10.25	12.53	70	70	20.39	23.67	59.86	58.86	12.53	13.90	2.28	1.37	1.83
	K	154.36	154.61	15	15	81.71	93.02	87.65	76.59	154.61	156.23	0.25	1.62	0.93
	S	7.45	8.59	20	20	24.14	28.44	3.31	0.15	8.59	9.90	1.14	1.31	1.23
Gobhi sarson-black gram	N	142.89	145.91	65	65	119.72	131.31	88.17	79.60	145.91	148.84	3.02	2.93	2.98
	P	10.25	12.39	90	90	23.49	26.83	76.76	75.56	12.39	13.76	2.14	1.37	1.76
	K	154.36	154.42	15	15	93.78	100.61	75.58	68.81	154.42	156.18	0.06	1.76	0.91
	S	7.45	8.35	20	20	28.45	31.49	-1.00	-3.14	8.35	9.76	0.90	1.41	1.16
Chickpea–sesame	N	142.89	154.31	35	35	71.67	87.98	106.22	101.33	154.31	156.41	11.42	2.10	6.76
	P	10.25	11.38	80	80	15.26	19.10	74.99	72.28	11.38	11.34	1.13	-0.04	0.55
	K	154.36	153.58	0	0	33.90	39.45	120.46	114.13	153.58	154.01	-0.78	0.43	-0.18
	S	7.45	7.19	0	0	8.05	10.08	-0.60	-2.89	7.19	7.36	-0.26	0.17	-0.04

Table 2: Continue...

Table 2: Continue...

Field pea-sesame	N	142.89	154.58	35	35	99.86	110.22	78.03	79.36	154.58	157.58	11.69	3.00	7.35
	P	10.25	11.50	80	80	22.33	24.64	67.92	66.86	11.5	11.58	1.25	0.08	0.67
	K	154.36	153.87	0	0	45.76	49.43	108.6	104.44	153.87	154.85	-0.49	0.98	0.24
	S	7.45	7.25	0	0	12.16	13.47	-4.71	-6.22	7.25	7.49	-0.2	0.24	0.02
Mustard-sesame	N	142.89	143.62	80	80	86.1	97.77	136.79	125.85	143.62	144.06	0.73	0.44	0.59
	P	10.25	11.73	70	70	18.89	21.69	61.36	60.04	11.73	12.15	1.48	0.42	0.95
	K	154.36	150.38	15	15	68.65	78.97	100.71	86.41	150.38	148.27	-3.98	-2.11	-3.05
	S	7.45	7.55	20	20	23.73	27.94	3.72	-0.39	7.55	7.71	0.1	0.16	0.13
Gobhi sarson-sesame	N	142.89	143.09	70	70	103.94	113.49	108.95	99.6	143.09	143.95	0.2	0.86	0.53
	P	10.25	11.58	90	90	21.81	24.68	78.45	76.9	11.58	12.1	1.33	0.52	0.93
	K	154.36	149.36	15	15	80.72	86.55	88.64	77.81	149.36	146.31	-5	-3.05	-4.03
	S	7.45	7.30	20	20	27.92	31.67	-0.47	-4.37	7.3	7.6	-0.15	0.3	0.07
Chickpea-soybean	N	142.89	156.82	35	35	139.62	150	38.27	41.82	156.82	165.11	13.93	8.29	11.11
	P	10.25	12.08	80	80	19.18	22.81	71.07	69.27	12.08	12.89	1.83	0.81	1.32
	K	154.36	155.69	20	20	57.03	65.29	117.33	110.4	155.69	157.43	1.33	1.74	1.54
	S	7.45	8.24	0	0	10.17	11.85	-2.72	-3.61	8.24	8.44	0.79	0.2	0.5
Field pea-soybean	N	142.89	160.60	35	35	170.88	178.37	7.01	17.23	160.6	165.69	17.71	5.09	11.4
	P	10.25	12.19	80	80	26.28	28.91	63.97	63.28	12.19	13.21	1.94	1.02	1.48
	K	154.36	155.83	20	20	70.26	74.93	104.1	100.9	155.83	157.58	1.47	1.75	1.61
	S	7.45	8.67	0	0	14.55	15.87	-7.1	-7.2	8.67	8.68	1.22	0.01	0.62
Mustard-soybean	N	142.89	146.17	80	80	150.62	159.22	72.27	66.95	146.17	148.17	3.28	2	2.64
	P	10.25	12.38	70	70	22.75	25.64	57.5	56.74	12.38	13.83	2.13	1.45	1.79
	K	154.36	156.50	35	35	91.72	103.89	97.64	87.61	156.5	156.83	2.14	0.33	1.24
	S	7.45	9.17	20	20	26.11	30.27	1.34	-1.1	9.17	9.93	1.72	0.76	1.24
Gobhi sarson-soybean	N	142.89	145.12	70	70	167.75	171.2	45.14	43.92	145.12	147.18	2.23	2.06	2.15
	P	10.25	12.22	90	90	26.01	28.74	74.24	73.48	12.22	13.58	1.97	1.36	1.67
	K	154.36	156.39	35	35	103.68	110.7	85.68	80.69	156.39	156.37	2.03	-0.02	1.01
	S	7.45	9.11	20	20	30.44	33.79	-2.99	-4.68	9.11	9.87	1.66	0.76	1.21

SY_1= RY_1+ KY_1 (*Rabi* 2014-15+ *Kharif* 2015).

SY_2= RY_2+ KY_2 (*Rabi* 2015-16+ *Kharif* 2016).

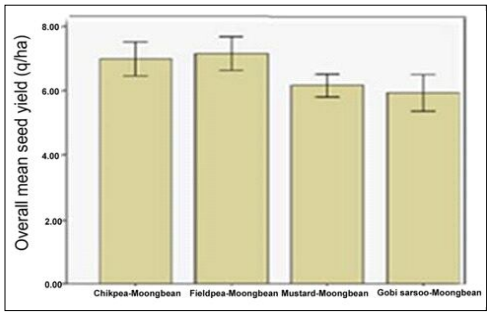


Fig 1(a): Overall mean seed yield of moongbean grown during *kharif* 2015 and 2016 in *rabi* oil seed/pulse *kharif* oil seed/pulse systems.

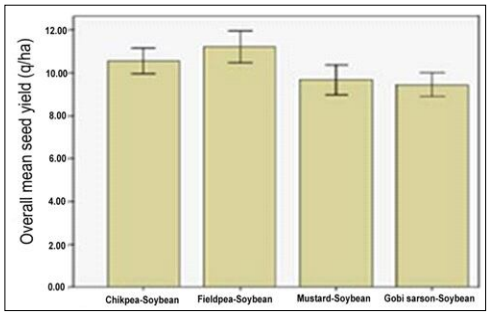


Fig 1b): Overall mean seed yield of soybean grown during *kharif* 2015 and 2016 in *rabi* oil seed/pulse *kharif* oil seed/pulse systems.

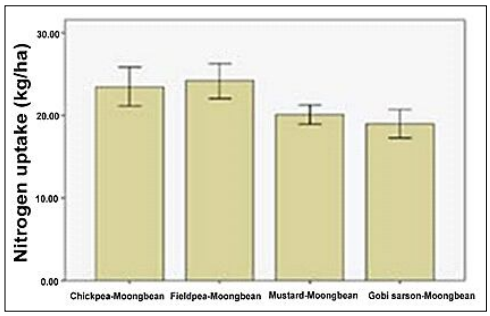


Fig 2(a): Overall mean nitrogen uptake by seed of moongbean grown during *kharif* 2015 and 2016 in *rabi* oil seed/pulse-*kharif* oil seed/pulse system.

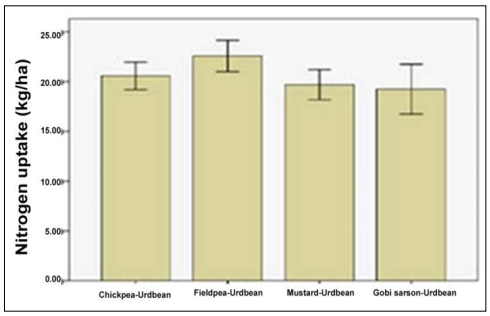


Fig 2(b): Overall mean nitrogen uptake by seed of urdbean grown during *kharif* 2015 and 2016 in *rabi* oil seed/pulse-*kharif* oil seed/ pulse system.

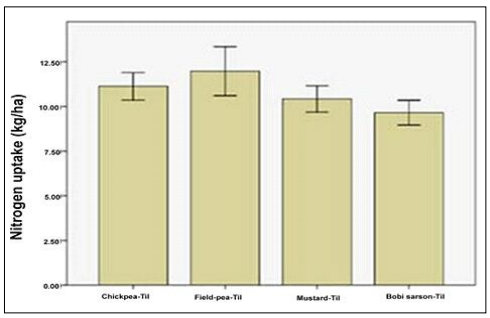


Fig 2(c): Overall mean nitrogen uptake by seed of til grown during *kharif* 2015 and 2016 in *rabi* oil seed/pulse-*kharif* oil seed/pulse system.

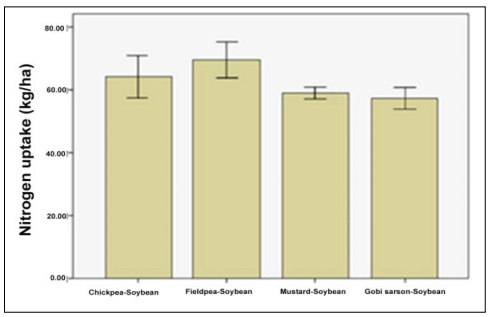


Fig 2(d): Overall mean nitrogen uptake by seed of soybean grown during *kharif* 2015 and 2016 in *rabi* oil seed/pulse-*kharif* oil seed/ pulse system.

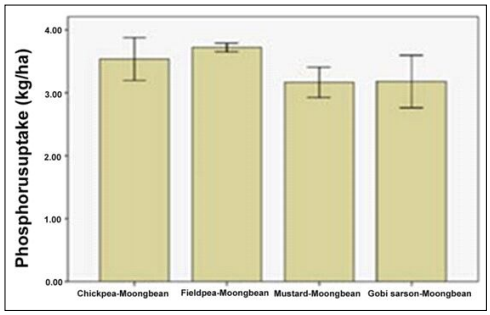


Fig 3(a): Overall mean phosphorus uptake by seed of moongbean grown during *kharif* 2015 and 2016 in *rabi* oil seed/pulse-*kharif* oil seed/pulse system.

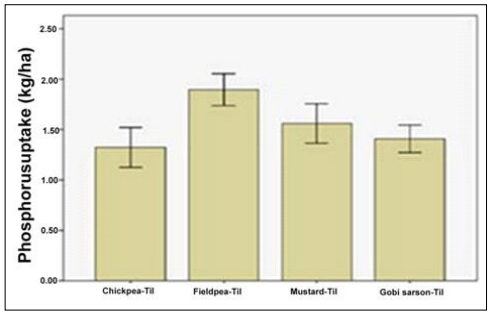


Fig 3(b): Overall mean phosphorus uptake by seed of til grown during *kharif* 2015 and 2016 in *rabi* oil seed/pulse-*kharif* oil seed/ pulse system.

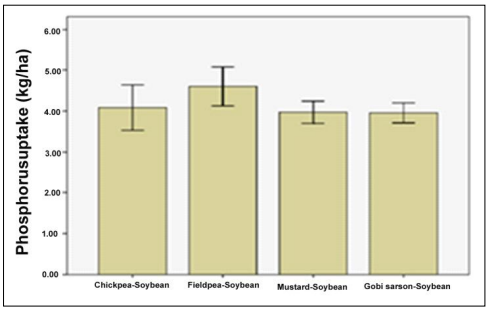


Fig 3(c): Overall mean phosphorus uptake by seed of soybean grown during *kharif* 2015 and 2016 in *rabi* oil seed/pulse-*kharif* oil seed/pulse system.

green gram (1.85 kg/ha) and mustard- black gram systems (1.83 kg/ha). Balance of phosphorus based on initial soil status and actual soil status after two crop cycles was positive under all the cropping systems. Sharma *et al.* (2000) also reported similar findings under all the *rabi* oilseed/pulse-*kharif* oilseed/pulse systems. Balance of available potassium showed a positive balance in all the cropping systems except for chickpea-sesame (-0.18 kg/ha), mustard-sesame (-3.05 kg/ha) and gobhi sarson- sesame systems (-4.03 kg/ha). This might be due to the fact that a dynamic equilibrium is known to exist between slowly available and exchangeable forms of potassium in soil. The results are in close agreement with those of Sharma *et al.* (2000). Available sulphur showed a positive balance in all the cropping systems except for chickpea-sesame system (-0.04 ppm). Numerically highest available sulphur was recorded in oilseed crops as compared to pulse crops. This might be due to the fact that recommended doses of sulphur was applied only in oilseed crops.

CONCLUSION

On the basis of two years study, field pea-green gram cropping system proved to be the most promising, viable and sustainable cropping system under dryland ecosystem of Jammu.

Conflict of interest

All authors declared that there is no conflict of interest.

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