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Weed dynamics in pulses cultivated in summer-fallows of double cropped lowland rice fields of Northern Kerala

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ABSTRACT

A field study was undertaken to find the weed dynamics in different pulse crops in summer-fallows of lowland rice fields under varying nitrogen doses during summer 2018. Among grasses, sedge and broad-leaved weeds *Oryza sativa*, *Cyperus rotundus* and *Boerhavia diffusa*, respectively were dominant in the field where pulses are grown. Absolute density of weeds was lesser in plots where red gram was cultivated with 75% and 50% of the recommended dose of nitrogen (RDN). Blackgram (50% RDN) was effective in smothering weeds. The dry matter production of weeds was the highest in fallows. The N removal by weeds was higher in fallow and that of P and K were at par in all treatments. The leaf area index (LAI) (100 and 50% RDN), crop growth rate (CGR) (50% RDN), yield (50% RDN) were significant for cowpea. Cowpea and red gram performed better among the different pulses in terms of yield. There was no significant difference in yield of pulses under varying levels of N, indicating that the lower level of N (50% RDN) will be sufficient.

Utilisation of summer-fallows by raising different crops increases system productivity (Varughese *et al.* 2007, Adarsh *et al.* 2019). Pulse crops are potential candidates for considering in summer rice-fallows as they fix atmospheric nitrogen (Pillai *et al.* 2007, Porpavai *et al.* 2011) and enhance the physical, chemical and biological properties of soil. They are very good sources of protein with low glycaemic index, low gluten and even acts as a functional food (Rao 2002). Weeds are the major impediment to crop production. A major approach to reduce the predominance of any given weed species is to increase the diversity of crops within the cropping system. Hence, the inclusion of crops with different growth habits and requiring change in land configuration during summer in rice-based sequences can bring about changes in the weed species diversity and their population. In this context, a study was undertaken to assess the weed dynamics in different pulses grown during summer in the lowland double cropped rice-fallows.

The field study was undertaken in the double cropped lowland rice fields of Regional Agricultural Research Station, Pilicode, Kerala Agricultural University during summer 2018 (February to May 2018). Cowpea (var. *PGCP 6*), black gram (var. *Co 6*), green gram (var. *Co. 8*) and red gram (var. *APK 1*) were raised in the field selected for the study. Total rainfall of 110.5 mm was received during cropping season. The maximum and minimum temperature varied between 33°C and 34.5°C and 20.5°C and 26°C, respectively during the summer. The soil of the experimental site, which falls under the order Ultisol, was sandy clay loam in texture, extremely acidic in pH and, high in available nitrogen, phosphorus and potassium contents. The experiment was laid out in a randomised block design with thirteen treatments and replicated thrice. The treatments were a combination of 4 pulse crops (cowpea, blackgram, green gram and red gram) with 3 levels of nitrogen (100% RDN, 75% RDN and 50% RDN) and fallow during summer. Cowpea variety *PGCP 6*, green gram variety *Co 8*, black gram variety *Co 6* and red gram variety *APK 1* were used under the study. The plot size was 5 x 4 m. Dry matter of the weeds was estimated by sampling of weeds from 1 m^2 area. Weeds were uprooted from each plot with minimum damage to roots and dried under shade and then oven dried at 70 ± 5°C till constant weight was obtained, and expressed as g/m^2. The weed population was estimated by counting the number of weeds in each category *i.e.*, grasses, broad-leaved weeds and sedges and expressed in number/m^2. The plant analysis was done in such a way that samples were

dried to constant weight in an electric hot air oven at 70 ± 5°C, ground into fine powder and analysed. Modified micro Kjeldahl method, Vanado-molybdo phosphoric yellow colour method using spectrophotometer and flame photometry method have been used for chemical analysis of N, P and K, respectively (Jackson, 1973). Content of nutrients removed by weeds were calculated from the values of dry matter content and per cent nutrient content of weed. Weed smothering efficiency (WSE) was calculated as:

$$WSE = \frac{WdwC - WdwT}{WdwC} \times 100$$

where,

WdwC: Weed dry weight in control (g/m^2)

WdwT: Weed dry weight in treated plot (g/m^2)

$$\text{Nutrient removal by weed (kg/ha)} = \frac{\text{Nutrient content (\%) x Dry matter (kg/ha)}}{100}$$

LAI and CGR (expressed in g/m^2/day) were worked out using the formula suggested by Watson (1947). The net assimilation rate (NAR) was calculated by the formula given by Gregory (1926) and expressed in g/cm^2/day. SPAD Chlorophyll Meter Reading (SCMR) was taken by "Chlorophyll meter SPAD 502 plus" manufactured by Spectrum Technologies, USA (Model 2900P). The observation was taken during morning (between 09.00 a.m. to 11.00 a.m.). The third apical leaf of pulse crop was selected for the measurement. The data generated from the experiment was analysed by following the techniques of analysis of variance (ANOVA) for randomized block design (Cochran and Cox 1965). Significant differences among treatments were observed, and LSD (least significant difference) values at 5 per cent level of significance were calculated for comparison of means.

The weed composition during summer season at 20 and 40 DAS (days after sowing) are furnished in **Tables 1** and **2,** respectively. The weeds comprised of grasses, *viz. Oryza sativa* and *Eleusine indica,* sedge, *viz. Cyperus rotundus* and broad-leaved weeds *viz. Boerhavia diffusa*, *Mollugo* sp. and *Euphorbia hirta*. At 20 DAS, there was no significant difference between treatments in the population of *Oryza sativa, Cyperus rotundus, Mollugo* sp. and *Euphorbia hirta*. The population of *Eleusine indica* was the highest in cowpea with 50% RDN, which was at par with black gram with 50% RDN, green gram with 50% RDN) and red gram with 50% RDN. The population of *Boerhavia diffusa* was the highest in fallow during summer which was at par with all the treatments except red gram with 100, 75 and 50% RDN, where the population was significantly less. At 40 DAS, there was no significant difference in the population of different weeds between treatments. But, the *Mollugo* sp. was absent in majority of the treatments (except cowpea with 100% RDN, cowpea with 50% RDN and green gram with 100% RDN, while certain new broad-leaved weeds, *viz. Euphorbia hirta* (green gram with 75% RDN), *Cleome rutidospermum* (cowpea with 75% RDN, cowpea with 50% RDN, green gram with 100% RDN and fallow during summer) and *Oldenlandia umbellata* (green gram with 75% and 50% RDN) appeared newly in certain treatments. Absolute density of weeds was no significant difference between treatments in the population of grasses and sedges at 20 and 40 DAS. With regard to broad-leaved weeds, at 20 DAS, the population was significantly less in red gram with 100, 75 and 50% RDN. However, at 40 DAS, all

Table 1. Effect of treatments on composition of weeds during summer crop at 20 DAS (no./m^2)

Treatment	Grasses					Sedge		Broad-leaved weeds				
	Oryza sativa		*Eleusine indica*		Sub total	*Cyperus rotundus*		*Boerhavia diffusa*		*Mollugo* sp.	*Euphorbia hirta*	Sub total
	Raw data	Trans-formed value	Raw data	Trans-formed value		Raw data	Trans-formed value	Raw data	Trans-formed value			
Cowpea with 100% RDN	65.9	9	17.6	4.1	83.5	206	13.7	548.3	23	14.3	18.3	580.9
Cowpea with 75% RDN	48.2	8.3	14.6	3.8	62.8	224	14.9	714	26	14	15.6	743.6
Cowpea with 50% RDN	81.8	11.6	47.6	6.7	129.4	241.6	13.5	429.3	20.6	14	16.7	460
Black gram with 100% RDN	40.3	8.8	14	3.7	54.3	212.3	14	575	23.9	6.3	20.6	601.9
Black gram with 75% RDN	107.2	12.4	16.3	4	123.5	201	13.9	603	24.5	18.6	14.3	635.9
Black gram with 50% RDN	125.1	12.1	40	6.3	165.1	44.6	6.4	479.3	21.7	15.3	18.6	513.2
Green gram with 100% RDN	66.2	8.9	21	4.5	87.2	62.3	7.54	409.6	19.9	16.3	23	448.9
Green gram with 75% RDN	71	10	20.6	4.4	91.6	240.3	14.4	450.6	21.2	19	18.6	488.2
Green gram with 50% RDN	71.6	8.1	43.6	6.1	115.2	86	8.5	526.3	22.8	14.6	20.6	561.5
Red gram with 100% RDN	51.2	8.3	15.6	3.9	66.8	123.3	10.8	304	16.2	18.3	17.3	339.6
Red gram with 75% RDN	69.9	9	18.7	4.3	88.6	87	7.84	266.3	15.6	15.6	21.3	303.2
Red gram with 50% RDN	76	10.3	39	5.6	115	29.3	5.05	249.6	15.4	17	19	285.6
Fallow during summer	49.3	9.7	18.3	4.2	67.6	179	13.1	774	27.2	19.3	21	814.3
LSD (p=0.05)	NS		1.9			NS		7.36		NS	NS	

treatments were at par with respect to broad-leaved weeds. The total population of weeds was significantly less in green gram with 100% RDN and red gram with 100, 75 and 50% RDN at 20 DAS. But at 40 DAS, the total weed population was significantly less in black gram and red gram with 50% RDN. At 20 DAS, the dry matter of weeds was significantly higher in cowpea with 50% RDN, green gram with 75% RDN and fallow during summer **Table 3**. At 40 DAS, the dry weight of weeds was significantly more in black gram with 100% RDN, green gram with 50% RDN and fallow during summer. At 20 DAS, there was no significant difference in weed smothering efficiency. At 40 DAS, the highest weed smothering efficiency was recorded in black gram with 50% RDN, which was at par with cowpea and black gram with 75% RDN, green gram with 100 and 75% RDN, red gram with 100, 75 and 50% RDN. At 20 DAS, the removal of N by weeds was significantly more in fallow during summer while it was at par in all other treatments. The removal of P and K did not significantly differ between treatments. At 40 DAS, N removal was significantly higher in fallow during summer which was at par with black gram with 100% and green gram with 50% RDN. The removal of P exhibited a trend similar to that of N. K removal did not differ significantly between treatments (**Table 3**).

The influence on LAI was obvious only in cowpea both at 20 DAS and 40 DAS whereas other pulses showed no significant difference among the treatments. The higher and on par LAI in cowpea at 100 and 50% did not have any adverse effect (**Table 4**). CGR was significantly more at red gram at 20 and

Table 2. Effect of treatments on composition of weeds during summer crop at 40 DAS (no./m^2)

Treatment	Grasses					Sedge		Broad-leaved weeds										
	Oryza sativa		*Eleusine indica*		Sub total	*Cyperus rotundus*		*Boerhavia diffusa*		*Mollugo* sp.		*Euphorbia hirta*		*Cleome rutidospermum*		*Oldenlandia umbellate*		Sub total
	Raw data	Transformed value	Raw data	Transformed value		Raw data	Transformed value	Raw data	Transformed value	Raw data	Transformed value	Raw data	Transformed value	Raw data	Transformed value	Raw data	Transformed value	
Cowpea with 100% RDN	102.6	10	6.6	1.9	109.2	372	18.5	510.6	19.9	6.7	1.9	0	0.7	0	0.7	0	-0.7	517.3
Cowpea with 75% RDN	109.3	10.2	20	3.8	129.3	241.3	14.7	460	21.3	0	0.7	0	0.7	32	3.7	0	-0.7	492
Cowpea with 50% RDN	152	11.6	20	3.8	172	392	18.3	422.6	20.3	13.3	2.5	0	0.7	13.3	2.5	0	0.7	449.2
Black gram with 100% RDN	89.3	8.8	13.3	3.2	102.6	221.3	13.7	536	22.8	0	0.7	0	0.7	0	0.7	0	0.7	536
Black gram with 75% RDN	102.6	10	20	3.8	122.6	228	14.8	529.3	22.2	0	0.7	0	0.7	0	0.7	0	0.7	529.3
Black gram with 50% RDN	52	7.1	6.6	1.9	58.6	64	6.6	302.6	17.2	0	0.7	0	0.7	0	0.7	0	0.7	302.6
Green gram with 100% RDN	158.6	12.5	6.6	1.9	165.2	64	6.7	441.3	20.9	13.3	3.2	0	0.7	26.7	4.3	0	0.7	481.3
Green gram with 75% RDN	96	7.6	20	3	116	234.6	14.9	366.7	19.1	0	0.7	6.6	1.9	0	0.7	6.7	1.9	380
Green gram with 50% RDN	177.3	12.9	0	0.7	177.3	360	18.5	421.3	20.4	0	0.7	0	0.7	0	0.7	6.7	1.9	428
Red gram with 100% RDN	121.3	10.9	0	0.7	121.3	290.6	16.1	486.6	21.1	0	0.7	0	0.7	0	0.7	0	0.7	486.6
Red gram with 75% RDN	178.7	12.8	26.6	5.1	205.3	121.3	10.8	360	17.9	0	0.7	0	0.7	0	0.7	0	0.7	360
Red gram with 50% RDN	126.7	9.3	6.6	1.9	133.3	133.3	8.9	158.6	12.2	0	0.7	0	0.7	0	0.7	0	0.7	158.6
Fallow during summer	89.3	9.3	0	0.7	89.3	145.3	10.5	868	29.4	0	0.7	0	0.7	6.6	1.9	0	0.7	874.6
LSD (p=0.05)	NS		NS			NS		NS		NS		NS		NS		NS		

Table 3. Effect of treatments on dry matter production and smothering efficiency and nutrient removal (NPK) of weeds during summer crop

Treatment	Dry matter production (g/m^2)		Weed smothering efficiency (%)		N (kg/ha)		P (kg/ha)		K (kg/ha)	
	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS
Cowpea with 100% N	30.80(3.28)	81.84	70.27	58.33	6.66(1.79)	15.50	0.78	2.50	3.51	11.00(2.30)
Cowpea with 75% N	35.62(3.55)	112.46	65.43	42.94	7.39(1.99)	16.70	0.55	2.20	2.50	10.90(2.20)
Cowpea with 50% N	47.39(3.76)	131.81	53.48	33.07	8.54(2.13)	22.50	1.14	3.20	5.07	11.00(2.30)
Blackgram with 100% N	43.65(3.70)	182.56	56.99	7.17	9.37(2.00)	29.70	0.73	5.50	2.93	18.60(2.70)
Blackgram with 75% N	34.13(3.50)	103.76	66.30	47.15	7.40(1.99)	15.90	0.87	2.80	3.55	11.90(2.30)
Blackgram with 50% N	21.62(3.04)	61.56	78.99	68.82	7.09(1.94)	12.40	0.64	1.10	2.89	6.90 (1.90)
Green gram with 100% N	22.78(3.09)	69.72	77.33	64.39	6.06(1.74)	12.80	0.62	1.20	3.38	7.00 (1.90)
Green gram with 75% N	61.44(4.06)	119.88	38.75	39.65	17.39(2.82)	17.00	1.43	3.30	5.62	14.10(2.60)
Green gram with 50% N	35.63(3.38)	156.71	65.15	20.10	8.25(2.00)	26.80	0.89	3.90	3.61	13.50(2.50)
Red gram with 100% N	26.44(3.21)	108.53	74.12	44.79	7.77(1.99)	24.70	0.59	2.40	2.94	14.50(2.60)
Red gram with 75% N	37.01 (3.32)	100.80	63.65	48.14	9.92(2.01)	20.20	1.07	2.40	3.05	12.80(2.40)
Red gram with 50% N	17.80(2.75)	66.94	82.99	66.07	6.03(1.64)	14.30	0.45	2.10	2.43	9.10(2.20)
Fallow during summer	102.45(4.62)	197.54	0*	0 †	134.89(4.06)	36.00	1.92	6.00	9.13	21.70(2.90)
LSD (p=0.05)	0.86	49.32	NS	25.89	1.09	11.00	NS	2.10	NS	NS

Figures in parentheses denote transformed values; *Values were not used for statistical analysis

Table 4. Effect of treatments on LAI, CGR, NAR, SCMR, yield attributes and grain weight (yield) of summer crop

Treatment	Leaf area index		Crop growth rate($g/m^2/day$)		Net assimilation rate ($g/cm^2/day$)		SPAD chlorophyll meter reading		No. of pods per plant	Grain weight (kg/ha)
	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS	20 DAS	40 DAS		
Cowpea with 100% N	0.291	1.160	1.18	4.00	1.40×10^{-3} (0.037)	0.28×10^{-3} (0.016)	43.36	58.69	22.8 (4.73)	1268
Cowpea with 75% N	0.212	0.858	0.89	3.03	1.40×10^{-3} (0.037)	0.28×10^{-3} (0.016)	44.64	60.62	15.8 (3.97)	1094
Cowpea with 50% N	0.362	1.288	1.44	4.57	1.41×10^{-3} (0.037)	0.26×10^{-3} (0.015)	44.39	59.24	27.4 (5.22)	1681
Blackgram with 100% N	0.035	0.209	0.35	1.69	2.58×10^{-3} (0.050)	0.70×10^{-3} (0.026)	35.32	41.44	22.4 (4.71)	418
Blackgram with 75% N	0.046	0.247	0.29	2.01	1.95×10^{-3} (0.043)	0.70×10^{-3} (0.025)	34.82	39.39	21.8 (4.63)	410
Blackgram with 50% N	0.036	0.214	0.33	1.62	2.34×10^{-3} (0.048)	0.62×10^{-3} (0.024)	32.19	39.69	25.4 (4.89)	521
Greengram with 100% N	0.102	0.390	0.57	1.82	1.67×10^{-3} (0.040)	0.35×10^{-3} (0.018)	34.56	42.86	15.6 (3.91)	337
Greengram with 75% N	0.056	0.472	0.33	2.51	1.63×10^{-3} (0.040)	0.54×10^{-3} (0.023)	30.04	38.35	35.2 (5.89)	842
Greengram with 50% N	0.065	0.477	0.40	2.73	1.75×10^{-3} (0.041)	0.54×10^{-3} (0.023)	29.56	39.52	33.2 (5.72)	753
Red gram with 100% N	0.075	0.499	3.73	11.19	14.69×10^{-3} (0.120)	2.29×10^{-3} (0.047)	44.60	44.68	140.3 (11.77)	1498
Red gram with 75% N	0.066	0.675	3.67	11.02	16.78×10^{-3} (0.128)	1.89×10^{-3} (0.043)	46.59	45.54	151.7 (12.02)	1852
Red gram with 50% N	0.073	0.623	3.76	11.20	15.20×10^{-3} (0.122)	2.18×10^{-3} (0.045)	44.84	44.08	178.3 (13.20)	1903
LSD (0.05)	0.077	0.381	0.31	2.21	0.015	0.009	5.32	4.81	2.10	527

Figures in parentheses denote transformed (square root) values

40 DAS, when compared to other pulses. At 20 DAS, CGR in cowpea was second highest but it was at par with black gram and green gram at 40 DAS. The CGR did not differ with varying levels of N in all the pulses at 40 DAS. The CGR did not differ with varying levels of N in all the pulses at 40 DAS (**Table 4**). NAR was recorded significantly higher in red gram among the pulses. The varying levels of N caused no appreciable difference in NAR of pulses at 20 and 40 DAS (**Table 4**). The SCMR was the highest in red gram followed by cowpea at 20 DAS but at 40 DAS cowpea had the highest SCMR (**Table 4**).This shows that the growth deciding physiological parameters were not detrimentally affected when the RDN was reduced to 50 per cent. The highest grain yield was obtained from red gram (irrespective of N level) and was at par with grain yield of cowpea at 50 per cent RDN. The reduced yield for black gram and green gram might be due to the weed competition and sudden change in temperature, relative humidity besides the irregular rainfall that occurred during the pod filling stage. Reducing the level of N did not result in a yield in a remarkable yield decline in any of the pulses. The higher grain yield obtained from red gram can be attributed to higher number of pods per plant, NAR and CGR. During summer, cowpea and red gram performed better among the different pulses, in terms of yield by effectively competing with weeds. This indicates that the lower level of N (50% RDN) will be sufficient for crops to get good crop canopy. The residual effect of the preceding two crops of rice can contribute to reduce N dose when pulses are raised during summer in double cropped rice lowlands (Meetei *et al.* 2020).

Among the summer crops the leaf area index of cowpea treated with 100 and 50 per cent RDN was significantly better. The yield was significantly higher in cowpea (with 50% of RDN) and in green gram with 75 and 50% of RDN. The highest yield was obtained in red gram with 50% of RDN. The overall nutrient uptake was the highest in red gram. The nutrient removal by weeds was the higher for N in fallow and was at par for P and K in all the treatments. It showed that cowpea and red gram effectively competes with weeds, gives maximum yield in minimum N added.

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