Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(6): 2294-2299
Received: 16-09-2019
Accepted: 20-10-2019

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Effect of different cropping systems and fertility levels on quality and physiological parameters of potato

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Abstract
A field experiment was conducted during 2017-18 and 2018-19 at ICAR- CPRI-RS, Gwalior M.P. during *kharif* and *rabi* to judge the "effect of different cropping systems and fertility levels on quality and physiological parameters of potato". The experiment was laid out in split-plot design with three replications. In main plots three cropping systems viz. M_1: Cowpea – Potato, M_2: Maize + Cowpea – Potato, M_3: Maize – Potato with five sub plots of fertility levels viz. F_1: 150% RDF, F_2: 125% RDF, F_3: 100% RDF, F_4: 75% RDF + 25% organic and F_5: 50% RDF + 50% organic replicate three times. Cowpea – potato based cropping system recorded maximum protein content in tuber viz. 7.55% on pooled basis, respectively as compare to other cropping systems. Maximum protein content in tuber 7.61% recorded by 75% RDF + 25% N through FYM. Cowpea – potato based cropping system recorded maximum starch content in tuber viz. 12.93% on pooled basis, respectively as compare to other cropping systems. Maximum starch content in tuber 13.62% recorded by 50% RDF + 50% N through FYM. Maize + Cowpea – potato based cropping system recorded maximum water content in tuber viz. 21.11% on pooled basis, respectively as compare to other cropping systems. Maximum water content in tuber 20.58% recorded by 100% RDF. At stage 0-30 DAP, 30-60 DAP and 60 to maturity stage absolute growth rate, crop growth rate, leaf area index and leaf area duration significantly were recorded higher under the cowpea-potato based cropping system. At 60 to maturity stage, 75% RDF + 25% N through FYM significant result of absolute growth rate, crop growth rate and leaf area index was found during both the years which was at par with 125% RDF. At 30, 60 and maturity stage cowpea-potato based cropping system recorded highest value of LAD at all the stages of crop growth, highest LAD was registered under (125% RDF).

Keywords: growth, leaf area, potato, protein, starch and tuber

Introduction
Potato (*Solanum tuberous* L.) is a carbohydrate-rich, but low fat food crop and herbaceous annual that grow up to 100 cm and contributes substantially towards food and nutritional security in the world which is originated in the high Andean hills of South America. The potato can be distinguished from cereals like rice and wheat for its higher capacity to produce dry matter, which is about 47.6 kg/ hectare/ day. The average raw material composition of a potato tuber is as follows: dry matter (20%), starch (13-16%), total sugars (0-2%), protein (2%), fibre (0.5%), lipids (0.1%), vitamin A (trace/ 100 g fresh weight), vitamin C (31 mg/ 100 g fresh weight), minerals (trace), ash (1-1.5%), amylose (22-25%) and glycoalkaloids (< 1 mg/ 100 g fresh weight) as an ant nutritional factor. In some states of India, cultivation, supplying, trading and exporting of Kufri Chandramukhi is done. Kufri chandramukhi variety is highly demanded in the market and are widely supplied all over the world. These potatoes are high nutritious value and effective for health. These products are processed by the experts of the country and are tested also. The current global production of potato is around 388.2 million tonnes and China being the biggest producer globally, India ranks 2nd in area and production of potato in the world after China which contribute 11 per cent of world potato production. In India potato production is mainly confined to Uttar Pradesh, West Bengal, Madhya Pradesh, Punjab, Assam, Gujarat and Haryana. In India, it is grown on an area of 2.179 million hectares with the production of 48.6 million tonnes (Anonymous, 2017) [2]. Cowpea-potato, Maize + cowpea – potato, Maize – potato cropping system is an important system and are being practiced to generate income and produce more food per unit of land to meet the rapidly growing population. Nutrient management on cropping system basis is more efficient and judicious than sole crop basis.

because the residual effects of fertilizer applied to one crop are exploited by the succeeding crop. (Singh and Kushwaha, 2006) [8].Therefore, there is need to optimize nutrient requirement in potato based cropping system through organic and inorganic sources. Several studies have been conducted and recommendations have been made for fertilizer requirement of individual crop, but fertilizer recommendations for intercropping systems are very much limited as it depends upon population and yield potential of the component crops in intercropping system. Fertilization in legume crops is important at initial stages. Nutrients in soil solution are replenished either by desorption from soil surface, mineralization of soil organic matter or by addition of fertilizers. Fertilizer application is one of major production input recognized in any crop-production system (Rana *et al*., 2001) [7]. Considering the above fact an experiment was conducted in maize to judge the "effect of different fertility levels and cropping systems on quality and physiological parameters of potato var. kufri chandramukhi.

Materials and Methods

The present investigation on "effect of different cropping systems and fertility levels on quality and physiological parameters of potato" was carried out at ICAR-CPRI-RS, Gwalior (M.P.) during *kharif* and the following *rabi* season of 2017-18 and 2018-19. The experimental soil was silty clay loam soil in texture, neutral in reaction (pH 6.84), low in organic C (0.47%), and available N (180.30 kg/ha), medium in available P (13.15 kg/ha) and high in available K (270.55 kg/ha). The experiment was laid out in split-plot design with three replications. Planting pattern were assigned to main plots and fertility level practices in sub plots. In main plots three cropping systems viz. M_1: Cowpea – Potato, M_2: Maize + Cowpea – Potato, M_3: Maize – Potato with five sub plots of fertility levels viz. F_1: 150% RDF, F_2: 125% RDF, F_3: 100% RDF, F_4: 75% RDF + 25% organic and F_5: 50% RDF + 50% organic replicate three times. The gross plot size of the one plot was 4.8 m × 4.0 m. Maize hybrid variety 'MRM-3777' and cowpea variety 'Ankur' was sown during *kharif* and potato 'Kufri chandramukhi' during *rabi* with a seed rate of 20 kg, 25 kg and 30 q/ha, respectively and a recommended fertilizer dose of 120:60:40 kg N : P_2O_5 : K_2O kg/ha, respectively for maize and cowpea 18:46:0 kg N : P_2O_5 : K_2O kg/ha and 180:80:120 kg N : P_2O_5 : K_2O kg/ha, respectively potato crop. The sowing of maize and cowpea in sole as main crop and cowpea used as intercrop in main crop maize in additive series. Maize, cowpea and potato at spacing of 60 cm from row to row and 20 cm from plant to plant with manually.

Results and Discussion

Quality parameter of potato

Protein content in tuber (%)

Protein content of tuber used as a quality parameter in potato crop. Effect of different cropping systems and nutrient application had significant effect on tuber protein content during both the years. Cowpea – potato based cropping system recorded maximum protein content in tuber on pooled basis respectively, as compare to other cropping systems. Different sources of nutrient application gave higher tuber protein content. While maximum protein content in tuber 7.61% recorded by 75% RDF + 25% N through FYM. This may be due to availability of available N nutrient in soil was sufficient to full fill the requirement of N in sufficient amount for their optimal growth and development. Therefore, uptake of N nutrient was in sufficient amount by the plant consequently its translocation to tuber owing to that higher protein in tuber. This may be due to higher N content in tuber as compare to other treatment. Ahmed *et al.* (2015) [1], kumar *et al.* (2011) and Taye (2011).

Starch content in tuber (%)

Starch content of potato are main concern when it is used for processing purpose especially for chips and french fries making. They also affect processing costs because the oil absorption rates during frying are related to dry matter levels. Higher dry matter contributes to higher recovery rate and better quality of the processed product. Different treatment of nutrient application gave significant effect on different cropping systems during both the years and pooled basis. Cowpea – potato based cropping system recorded maximum starch content in tuber, respectively as compare to other cropping systems. Effect of different treatment of nutrient application were significantly at maximum starch content in tuber recorded by 50% RDF + 50% N through FYM. However, 150% RDF treatment gave minimum value of starch content.

Dry matter content in tuber (%)

Different treatment of nutrient application did not gave significant effect on different cropping systems during both the years and pooled basis. 100% RDF recorded maximum dry matter content in tuber on 2018-19, respectively as compare to other cropping systems. This may be due to higher transportation of accumulated food material from source to sink efficiently owing to positive effect of FYM on translocation of photosynthates by the increasing the availability of growth regulator to plant. This result also supported by Ahmed *et al.* (2015) [1] and Ram *et al.* (2017) [6] as shown in table 1.

Table 1: Effect of different cropping systems and fertility levels on quality parameters i.e., protein content, starch content and dry matter tubers of potato on pooled basis.

Treatment	Quality parameters of potato								
	Protein in tuber (%)			Starch content in tuber (%)			Dry matter% in tuber		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Main plot	Main plot								
M_1:Cow pea –potato	7.50	7.61	7.55	12.81	13.05	12.93	19.55	20.72	20.14
M_2:Maize + cowpea – Potato	7.42	7.53	7.48	12.60	12.80	12.70	20.11	21.01	20.56
M_3:Maize- Potato	7.37	7.55	7.46	11.97	12.31	12.14	20.22	20.05	20.13
S.E.(m)±	0.04	0.04	0.03	0.25	0.15	0.14	0.34	0.27	0.22
C.D. (at 5%)	0.16	0.16	0.09	NS	NS	0.47	NS	NS	NS
Sub plot									
S_1: 150% RDF	7.47	7.62	7.55	11.57	11.91	11.74	20.42	20.18	20.30
S_2: 125% RDF	7.42	7.59	7.51	12.06	12.28	12.17	20.12	20.48	20.30
S_3:100 RDF	7.35	7.51	7.43	12.26	12.59	12.43	19.51	21.66	20.58

S_4: 75% RDF + 25% N through FYM	7.55	7.67	7.61	12.89	13.11	13.00	20.54	20.47	20.50
S_5: 50% RDF + 50% N through FYM	7.35	7.42	7.38	13.53	13.70	13.62	19.21	20.19	19.70
S.E.(m)±	0.06	0.07	0.04	0.27	0.24	0.18	0.38	0.36	0.26
C.D. (at 5%)	0.17	0.19	0.12	0.80	0.69	0.51	NS	1.06	NS
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS

Physiological parameters

Growth analysis technique has made substantial contribution to the current understanding of the physiological basis of yield variation in different crops. Efforts to relate crop yields to canopy architecture began in the early 20th century with the development of "growth analysis" by British plant physiologists. They recorded total plant dry weight (W) and leaf area (L) in the growing season.

In fact, leaf is the factory for the conversion of solar energy into the chemical energy for the growth and development of plants. Leaf area or photosynthetic area fairly gives a good idea of the photosynthetic capacity of the plant. The AGR, CGR, LAI, LAR and LAD are the important growth parameters influencing yield which are dependent not only on the environmental but also on the different sources of nutrient management practices.

Absolute growth rate and crop growth rate

The different nutrient treatments influenced AGR and CGR significantly at all the crop growth stages during both the years and pooled basis. The perusal of data in Table 2, Table 3 and Fig. 1 to fig 4 revealed that the AGR and CGR, in general, tended to increase up to 30-60 DAP and then decrease up to 60-maturity stage in all the treatments. It may be due to starting of abscission and senescence and aging of leaves at later stages of crop growth. Both AGR and CGR increases significantly with increasing fertility level (150% RDF and 100% RDF), which was superior with remaining all fertilizer levels.

Table 2: Effect of different cropping systems and fertility levels on quality and physiological parameters AGR and CGR of potato on pooled basis

Treatment	AGR g/plant /day								
	30 DAP			60 DAP			Maturity		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Main plot									
M_1:Cow pea –potato	0.13	0.11	0.12	1.28	1.26	1.27	1.93	2.06	1.99
M_2:Maize + cowpea – Potato	0.10	0.11	0.10	1.23	1.27	1.25	1.75	1.88	1.81
M_3:Maize- Potato	0.08	0.10	0.09	1.07	1.30	1.18	1.58	1.49	1.53
S.E.(m)±	0.00	0.01	0.00	0.03	0.03	0.02	0.05	0.07	0.04
C.D. (at 5%)	0.01	NS	0.01	0.10	NS	0.06	0.21	0.27	0.14
Sub plot									
S_1: 150%	0.11	0.11	0.11	1.45	1.51	1.48	1.69	1.67	1.68
S_2: 125% RDF	0.10	0.09	0.10	1.10	1.27	1.19	1.89	1.92	1.90
S_3:100% RDF	0.10	0.12	0.11	1.14	1.22	1.18	1.69	1.68	1.68
S_4: 75% RDF + 25% N through FYM	0.11	0.10	0.10	1.15	1.27	1.21	1.89	2.01	1.95
S_5: 50% RDF + 50% N through FYM	0.09	0.11	0.10	1.13	1.10	1.11	1.60	1.77	1.68
S.E.(m)±	0.00	0.01	0.00	0.03	0.04	0.03	0.08	0.13	0.07
C.D. (at 5%)	0.01	0.02	0.01	0.10	0.12	0.08	NS	NS	0.21
Interaction	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG

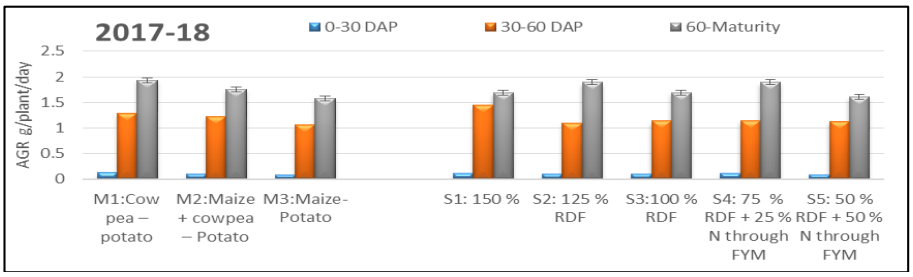

Fig 1: Effect of different cropping systems and fertility levels on quality and physiological parameters AGR of potato during 2017-18

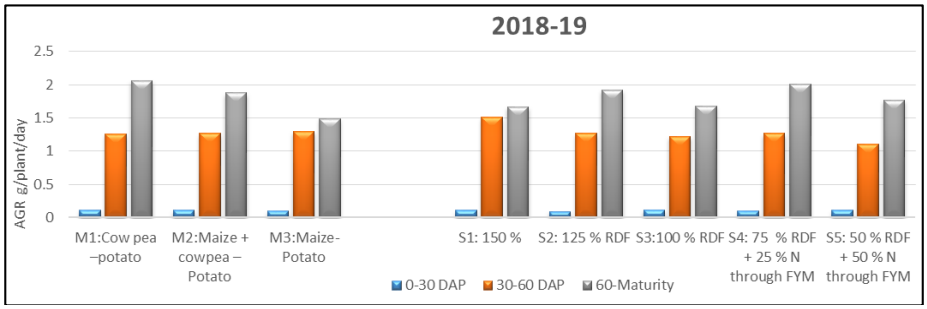

Fig 2: Effect of different cropping systems and fertility levels on quality and physiological parameters AGR of potato during 2018-19

Table 3: Effect of different cropping systems and fertility levels on quality and physiological parameters CGR of potato on pooled basis

Treatment	CGR g/m^2/ day/plant								
	0-30 DAP			30-60 DAP			60-Maturity		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Main plot									
M_1:Cow pea –potato	1.11	0.94	1.03	10.70	10.47	10.59	16.07	17.17	16.62
M_2:Maize + cowpea – Potato	0.82	0.90	0.86	10.23	10.59	10.41	14.54	15.69	15.12
M_3:Maize- Potato	0.63	0.83	0.73	8.91	10.83	9.87	13.15	12.38	12.77
S.E.(m)±	0.01	0.04	0.02	0.22	0.23	0.16	0.44	0.57	0.36
C.D. (at 5%)	0.05	NS	0.08	0.87	NS	0.52	1.73	2.24	1.18
Sub plot									
S_1: 150% RDF	0.96	0.92	0.94	12.10	12.62	12.36	14.06	13.93	14.00
S_2: 125% RDF	0.83	0.79	0.81	9.21	10.61	9.91	15.74	15.97	15.85
S_3:100% RDF	0.80	1.02	0.91	9.46	10.17	9.82	14.07	13.99	14.03
S_4: 75% RDF + 25% N through FYM	0.91	0.84	0.87	9.58	10.62	10.10	15.77	16.76	16.26
S_5: 50% RDF + 50% N through FYM	0.77	0.88	0.83	9.40	9.15	9.28	13.30	14.75	14.03
S.E.(m)±	0.02	0.04	0.02	0.28	0.34	0.22	0.67	1.04	0.62
C.D. (at 5%)	0.06	0.13	0.07	0.83	0.99	0.63	NS	NS	1.75
Interaction	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG

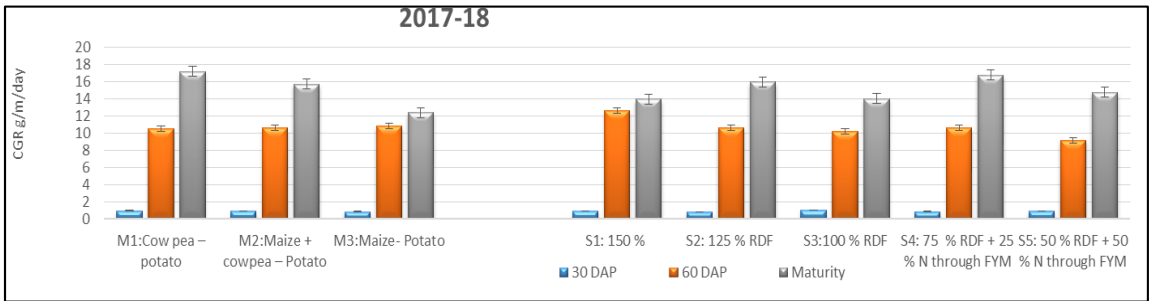

Fig 3: Effect of different cropping systems and fertility levels on quality and physiological parameters CGR of potato during 2017-18

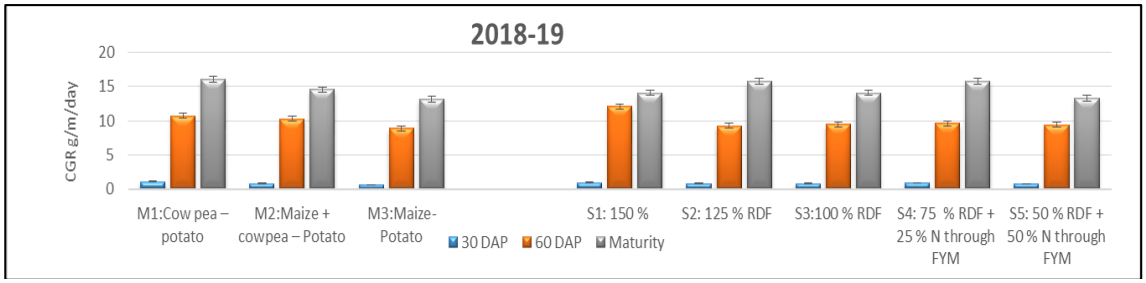

Fig 4: Effect of different cropping systems and fertility levels on quality and physiological parameters CGR of potato on 2018-19

Leaf area index (LAI)

The different nutrient application treatments influenced this parameter significantly at all the crop growth stages during both the years and pooled basis. The perusal of data in Table 4. Revealed that the LAI, in general, tended to increase up to 30-60 DAP and then decrease up to 60-maturity stage in all the treatments. It may be due to starting of abscission and senescence and aging of leaves at later stages of crop growth. At 30, 60 and maturity stage cowpea-potato based cropping system recorded highest value of LAI at all the stages of crop growth 1.38, 5.32 and 5.71 at 2017-18, 2018-19 and pooled basis, respectively.

Combination of different fertility level had considerable effect on LAI. At 0-30, 30-60 and 60 to maturity stage highest LAI was registered under (125% RDF). This may be due to more availability, absorption of nutrients at later stages of plant growth caused more cell division and elongation, protein and carbohydrate synthesis, and root development, which ultimately resulted in vigorous plant growth. Vigorous plant growth promoted more number of compound leaves, leaves width and length therefore more LAI. This finding was alike with Koireng *et al.* (2018) [4], Meena *et al.* (2013) [5] and Sood (2007) [10] fig. 5 and 6**.**

Table 4: Effect of different cropping systems and fertility levels on quality and physiological parameters LAI of potato on pooled basis

Treatment	LAI/plant								
	0-30 DAP			30-60 DAP			60-Maturity		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Main plot									
M_1:Cow pea –potato	1.37	1.40	1.38	4.63	6.00	5.32	5.88	5.55	5.71
M_2:Maize + cowpea – Potato	1.06	1.31	1.19	3.88	4.77	4.33	4.41	4.92	4.67
M_3:Maize- Potato	0.84	0.97	0.90	3.18	3.94	3.56	3.31	3.89	3.60
S.E.(m)±	0.04	0.04	0.03	0.09	0.10	0.07	0.10	0.51	0.26
C.D. (at 5%)	0.15	0.14	0.09	0.37	0.38	0.22	NS	NS	0.84
Sub plot									
S_1: 150% RDF	1.08	1.20	1.14	4.02	4.93	4.48	4.66	5.11	4.89

S_2: 125% RDF	1.28	1.42	1.35	4.53	5.90	5.21	5.31	6.17	5.74
S_3:100% RDF	1.05	1.17	1.11	3.83	5.08	4.45	4.43	4.41	4.42
S_4: 75% RDF + 25% N through FYM	0.97	1.11	1.04	3.31	4.14	3.73	3.76	3.47	3.62
S_5: 50% RDF + 50% N through FYM	1.06	1.21	1.14	3.79	4.49	4.14	4.49	4.75	4.62
S.E.(m)±	0.03	0.05	0.03	0.16	0.14	0.11	0.16	0.37	0.20
C.D. (at 5%)	0.10	0.13	0.08	0.46	0.42	0.30	0.46	1.07	0.56
Interaction	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG

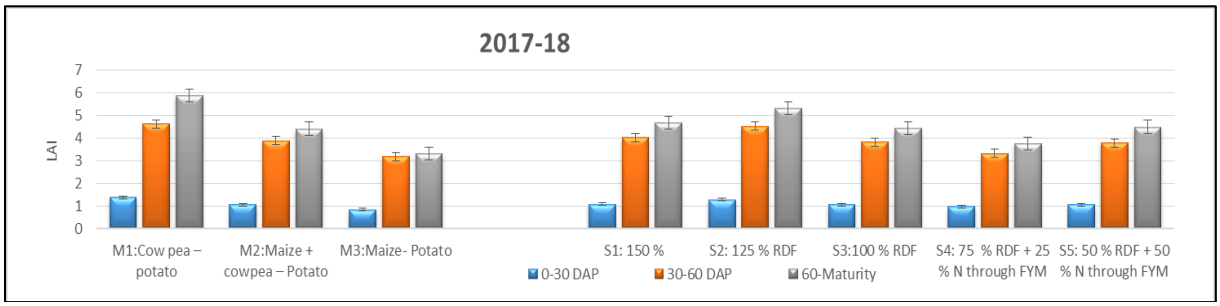

Fig 5: Effect of different cropping systems and fertility levels on quality and physiological parameters on LAI of potato during 2017-18

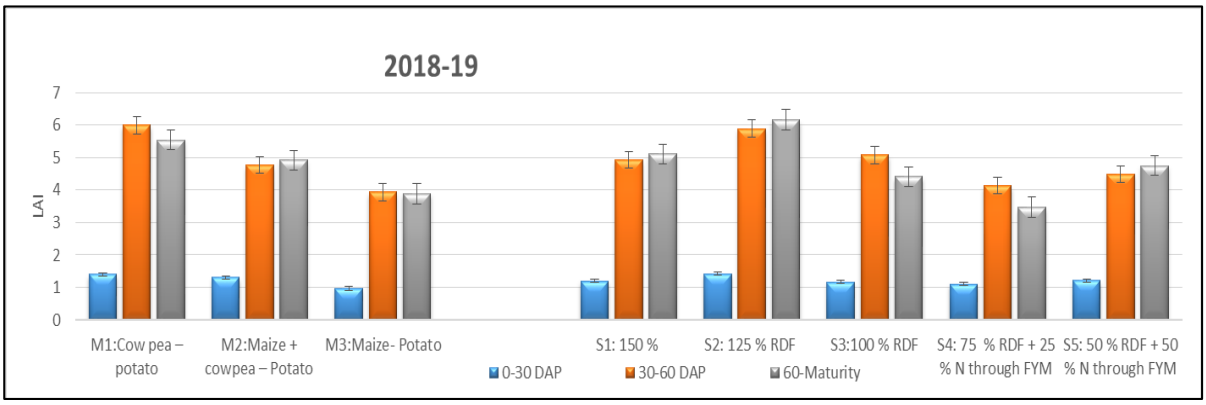

Fig 6: Effect of different cropping systems and fertility levels on quality and physiological parameters on LAI of potato during 2018-19

Leaf area ratio (LAR)

Leaf area ratio (LAR) is an important plant index, determining the capacity of plants in trapping solar energy for photosynthesis. The data related to leaf area index recorded at different growth stages (0-30, 30-60 DAP and 60-maturity) are presented in Table 5. It was observed that maximum LAR was recorded at 60 DAP when compared to other stages of crop growth through cowpea-potato based cropping system. Combination of different fertility level had considerable effect on LAR. Highest LAR was registered under (125% RDF). Lowest value of LAI was recorded with 75% RDF + 25% N through FYM. (Table 5).

Table 5: Effect of different cropping systems and fertility levels on quality and physiological parameters LAR of potato on pooled basis

Treatment	LAR cm^2/g								
	30 DAP			60 DAP			Maturity		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Main plot									
M_1:Cow pea –potato	448.72	523.38	486.05	133.81	179.76	156.78	71.76	85.77	78.76
M_2:Maize + cowpea – Potato	449.66	520.37	485.01	117.64	138.17	127.91	57.72	60.85	59.28
M_3:Maize- Potato	451.35	399.83	425.59	113.87	116.12	115.00	49.95	55.21	52.58
S.E.(m)±	21.90	22.34	15.64	4.81	3.72	3.04	2.23	4.84	2.66
C.D. (at 5%)	NS	87.72	51.02	NS	14.59	9.91	8.75	18.99	8.69
Sub plot									
S_1: 150% RDF	369.29	463.14	416.22	100.90	121.62	111.26	56.74	61.76	59.25
S_2: 125% RDF	542.71	613.29	578.00	154.50	172.81	163.66	68.59	76.10	72.34
S_3: 100% RDF	466.94	397.59	432.26	126.36	160.43	143.39	62.28	75.78	69.03
S_4: 75% RDF + 25% N through FYM	398.92	448.05	423.48	102.30	118.83	110.57	47.58	57.94	52.76
S_5: 50% RDF + 50% N through FYM	471.69	483.88	477.78	124.80	149.73	137.27	63.86	64.80	64.33
S.E.(m)±	20.22	27.00	16.87	6.19	5.55	4.16	2.25	5.75	3.09
C.D. (at 5%)	59.03	78.81	47.65	18.08	16.19	11.74	6.58	NS	8.72
Interaction	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG

Leaf area duration (LAD)

Leaf area duration (LAD) is the leaf area duration over a period of time. Due to the leaf-area duration changing with time, it is proportional to the area under the line on a graph of leaf – area index plotted against time. The data related to leaf area duration recorded at different growth stages (0-30, 30-60 DAP and 60-maturity, cowpea-potato based cropping system recorded highest value of LAD at all the stages of crop growth. It was observed that maximum LAD was recorded at maturity stage when compared to other stages of crop growth. Combination of different fertility level had

considerable effect on LAD. At 0-30, 30-60 and 60 to maturity stage highest LAD was registered under (125% RDF). While interaction effect was found significant in all stages of crop growth (Table 6).

Table 6: Effect of different cropping systems and fertility levels on quality and physiological parameters LAD of potato on pooled basis

Treatment	LAD/plant (days)								
	0-30 DAP			30-60 DAP			60-Maturity		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Main plot									
M_1:Cow pea –potato	20.49	20.95	20.72	89.92	110.98	100.45	157.62	173.24	165.43
M_2:Maize + cowpea – Potato	15.92	19.67	17.80	74.05	91.29	82.67	124.33	145.47	134.90
M_3:Maize- Potato	12.56	14.50	13.53	60.32	73.63	66.98	97.35	117.41	107.38
S.E.(m)±	0.59	0.54	0.40	1.54	1.12	0.95	2.35	8.98	4.64
C.D. (at 5%)	2.31	2.11	1.30	6.03	4.39	3.10	9.23	35.27	15.14
Sub plot									
S_1: 150% RDF	16.17	18.06	17.12	76.49	92.00	84.24	130.24	150.62	140.43
S_2: 125% RDF	19.23	21.28	20.25	87.17	109.74	98.46	147.67	181.02	164.34
S_3:100 RDF	15.82	17.62	16.72	73.26	93.76	83.51	123.92	142.36	133.14
S_4: 75% RDF + 25% N through FYM	14.53	16.69	15.61	64.21	78.76	71.48	106.14	114.19	110.17
S_5: 50% RDF + 50% N through FYM	15.88	18.22	17.05	72.70	85.59	79.15	124.18	138.67	131.43
S.E.(m)±	0.49	0.68	0.42	2.40	2.05	1.58	3.34	6.41	3.62
C.D. (at 5%)	1.43	1.97	1.18	7.01	5.98	4.46	9.76	18.71	10.21
Interaction	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG	SIG

Summary and Conclusion

Cowpea – Potato based cropping system recorded quality and physiological parameters during both the year and pooled basis respectively, as compare to other cropping systems with application of 75% NPK + 25% N through FYM. LAI, LAD and LAR recorded maximum with 125% RDF.

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