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Effect of Nutrient Management on Potato Preceding by Green Manuring Crops

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ABSTRACT: *Plant nutrients are important components of the intensive production system used for potatoes. Green manuring crops and nutrient management practices need to be improved for sustained and increased productivity. A field experiment was conducted for two consecutive years at Post Graduate Institute Research Farm of Mahatma Phule Krishi Vidyapeeth Rahuri during 2013- 2014 and 2014- 2015. To study the performance of nutrient management in potato preceding by green manuring crops. The results revealed that, incorporation of dhaincha at 50 % flowering stage as a green manuring crop in* kharif *season followed by growing of potato in* rabi *season with 100% general recommended dose of fertilizers (GRDF-120:60:120 N, P_2O5, K_2O kg ha^{-1} + 20 tons of farm yard manure ha^{-1}) found superior for recording higher nutrient uptake, grade wise potato yield and economics of potato.*

Key Words: *Green manuring crops, Potato, Nutrient management levels, nutrient budgeting, Nutrient uptake and gradewise potato yield.*

INTRODUCTION

Potato (*Solanum tubersum* L.) growth patterns and nitrogen distribution among plant segments are important parameters to adjust proper management practices for improved nitrogen uptake, grade wise potato yield and tuber quality. Furthermore, nitrogen availability within soil influences its magnitude, plant uptake pattern, accumulation and partitioning. In this regard, different simulation models were developed to predict potato growth, tuber production and adjust rational fertilization programs under different green manuring crops and nitrogen management levels.

Leguminous green manuring crop fixes the atmospheric nitrogen in the soil in the available form, improves the soil fertility, physical structure, and consumes excess soil moisture (Virdi *et al.*2005). Application of FYM and green manuring crops increased the potato yield at all levels of applied fertilizers indicating that saving of fertilizer due to combined application of FYM and green manuring crops (Grewal (1990).

Fertilization is an important factor in potato production technology to achieve optimum yield and quality of tubers. The potato is a plant with high nutrient demands because of forming abundant vegetative mass and a high quantity of tubers at the unit area. It is a great consumer of nitrogen, phosphorus and potassium (Fit and Hangan, 2010). High potato yields can only be obtained through the application of optimal nutrient doses in balanced proportions (Poljak *et al.*, 2007).

Addition of organic matter through green manures plays an important role in improving the soil physical properties, which often deteriorate under intensive cropping with Carbon in organic matter as a source of energy for microbes, improvement in beneficial microbial activities are also expected leading to better root and shoot growth, grain yield and quality. Therefore, in order to achieve enhanced and sustained yield through improvement of soil productivity, there is a need to work out proper management techniques to grow the green manure crops and there *in situ* incorporation in Potato cropping system in assured rainfed conditions (Ezekial *et al.* 1999).

MATERIALS AND METHODS

The field experiment was conducted for two consecutive years at Post Graduate Institute Research Farm of Mahatma Phule Krishi Vidyapeeth Rahuri

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during 2013- 2014 and 2014- 2015. It lies between 19^0 48′ N and 19^0 57′ N latitude and 74^0 19′ E and 74^0 32′ E longitude. The altitude varies from 495 to 569 meters above mean sea level. Climatologically, this area falls in the semi-arid tropics with annual rainfall ranged from 307-619 mm. the average annual precipitation is 520 mm. Out of total annual rainfall, about 80 per cent rains received from south-west monsoon (June-September). While, the rest received from North-East Monsoon (October-November). The rainfall is erratic and ill distributed in 15-45 rainy days in different year. The tract is in the shadow area, lying on eastern side of western ghat.

A soil sample was collected from the experimental field at the beginning of the experiment and physical and chemical properties were determined. It is observed that the soil of experimental site was sandy clay loam in texture. The chemical composition according to criteria laid by Muhr *et al.* (1965) indicated that soil was low in available nitrogen (168.33 kg ha^{-1}), medium in available phosphorus (22.43 kg ha^{-1}) and high (361.30 kg ha^{-1}) in available potash. The soil was moderately alkaline in reaction pH (8.06) with electrical conductivity of 0.48 ds m^{-1}. The field capacity 29.23% and permanent wilting point 15.60% respectively with Bulk density 1.26 mg m^{-3}.

The experiment was carried out in split-plot design with three replication. The net plot size was 2.40 m x 3.60 m (8.64 m^2). The green manuring crops were kept in main plots (*kharif* season) and nutrient management levels kept in sub plots (*rabi* season). The main plot treatments (*kharif* season) comprised of four green manuring crop *viz*., G_1 : sannhemp, G_2 : dhaincha, G_3 : cowpea, G_4 : greengram while the sub-plot treatments (*rabi* season) consisted of four nutrient management levels *viz*., F_1 : 100% GRDF (120:60:120 N, P_2O_5, K_2O kg ha^{-1} + 20 t ha^{-1} of FYM, F_2 : 100% RDF (120:60:120 N, P_2O_5, K_2O kg ha^{-1}), F_3 : 75% RDF (90:45:90 N, P_2O_5, K_2O kg ha^{-1}), F_4: 50% RDF (60:30:60 N, P_2O_5, K_2O kg ha^{-1}). A common seed treatment with *Azotobactor* + PSB) given to all treatments of potato. The recommended packages of practices were followed. The potato was planted after incorporation of green manuring crops.

The plant samples collected for dry matter studies at final uprooting of plants were used for nutrient uptake study. These plant samples were grinded into fine powder and 0.2 g of samples was used for chemical analysis i.e. estimation of N, P and K content in leaves, stem and tuber during both the years. The standard methods were followed for analysis. The uptake of NPK was worked out by multiplying the nutrient concentration by total dry matter of plant and expressed in kg ha^{-1} for each treatment.

For economic evaluation, the cost of cultivation, gross monetary returns (GMR), net monetary returns (NMR) and benefit: cost ratio (B:C) of 2013-14 and 2014-15 and pooled were computed treatment wise.

The data recorded were statistically analyzed by using technique "Analysis of Variance" method. (Panse and Sukhatme, 1967), (Fisher, 1970) and significance was determined for split plot design (Panse and Sukhatme, 1984). The standard error of mean (SE M±) was worked out. The total variance (S2) and d.f. (n-1) were partitioned into different possible sources. The variance due to replication, crops, fertilizer levels and their interaction were compared with error variance for finding out 'f' values and ultimately for testing the significance at 5% level (P=0.005). The tested errors for the treatment based on error variance were calculated wherever, the result found to be significant, critical difference (C.D. = S.E. (m) ± X √2 x t at error d.f.) was calculated.

The simple technique of analysis of variance may not be valid under two different seasonal conditions because of the error variances in the season and treatments and the season interaction may be significantly different. Hence, pooled analysis of the yield data of two years were carried out as the procedure outlined by Cochran and Cox (1957). The homogeneity of error variance was tested by applying the Bartlett's test. Firstly the pooled estimates of variance were computed as:

$$s^2 = \sum_{i=1}^{n} si^2 \; for \; i = 1$$

Then, the Chi-square test (k^2) was applied to the test of the homogeneity of 'n' variance with equal degree of freedom as:

$$X^2 = \frac{f(n\,loge\,S^2 - \Sigma \log e S^2)}{1 + \frac{n+1}{3nf}}$$

Where, f = degree of freedom.

RESULT AND DISCUSSION

Nutrient concentration and nutrient budgeting (Table 1 and 2) of green manuring plant samples revealed that the dhaincha crop recorded maximum concentration of NPK (%) 3.71, 0.46 and, 2.95 respectively, and nutrient budgeting recorded higher nitrogen, phosphorus and potassium (152.48, 18.90

and 121.24 kg ha-1) respectively, during *kharif,* 2013 and 3.95, 0.49 and 3.49 respectively, and nutrient budgeting recorded higher nitrogen, phosphorus and potassium (162.34, 20.13 and 143.43 kg $ha^{-1)}$ respectively, during *kharif,* 2014 followed by sannhemp crop. Similar findings were reported by Sharma and Mitra (1998), Peter *et al.* (2000), Griffen and Portar (2004), Khan *et al.* (2010) and Odhiambo, (2010).

The data regarding nutrient uptake of potato as influenced by different treatments during the year 2013-14 and 2014-15 are presented in Table 3 and 4, respectively, and graphically depicted in Fig.1 and 2. Data revealed that, at harvest combined residual effect of dhaincha (G_2) and F_1 treatment (100% GRDF) of potato registered significantly maximum nutrient uptake (kg ha^{-1}) in tuber and haulm during 2013-14 and 2014-15 year of experimentation. This might be due to combined residual effect of dhaincha as a green manuring crop along and higher level of fertilizer to the succeeding crops increase the availability of nutrients in the root rhizosphere, leads increase uptake of nutrients through the crop growth period.

The nutrient uptake depends upon the soil pH, oxidation potential, rhizoposition, nutrient concentration and root exudates. The chemical changes in the root rhizosphere were significantly influenced on nutrient solubility and uptake by plants. This might be because of nutrient management levels of fertilizer application provides balanced nutrition to potato which produce more yield and nutrient uptake. Hence, here was lesser content of residual soil available nitrogen, phosphorous and potassium. This results was in accordance with findings of Sharma *et al.* (2006), Sultani *et al.*(2007), Tejada *et al.* (2008), Campiglia *et al.* (2009), Zotarelli *et al.* (2012), Barghi *et al*. (2012) and Chauhan *et al.* (2014).

It is evident from the data (Table 5 and graphically depicted in Fig. 3, 4 and 5) during both the years of experimentation as well as when pooled, the grade wise potato yield (t ha^{-1}), were significantly higher with residual effect of dhaincha (G_2) and treatment F_1 *i.e* 100% GRDF, which was remained at par with residual effect of dhaincha (G_2) and treatment F_2 *i.e* 100% RDF. This might be because of beneficial residual effect of *kharif* dhaincha due to incorporation as a green manuring crop by fixing atmospheric nitrogen through biological means and which may be available to mineralization of plant residues thereby increases the growth and yield of succeeding crop.

On the other hand, during both the years of experimentation as well as when pooled (Table 5). The grade wise potato yield (t ha^{-1}) were significantly lower with residual effect of G_3. *i.e* cowpea and treatment F_4 *i.e* 50% RDF. A reduced nutrient supply leads stomatal closure, thus indirectly impairing photosynthesis. Delayed planting produced maximum small grade tubers than other nutrient management levels. This might be due to less favorable temperature available

Table 1
Nutrient concentration on dry weight basis in green manuring crops

Treatment	*Nutrient concentration (%)*					
	2013			*2014*		
	N	*P*	*K*	*N*	*P*	*K*
Green manuring crops						
G_1 - Sannhemp	2.18	0.39	1.62	2.83	0.45	2.16
G_2 - Dhaincha	3.71	0.46	2.95	3.95	0.49	3.49
G_3 - Cowpea	2.03	0.18	1.04	2.68	0.23	1.58
G_4 - Greengram	2.13	0.24	1.12	2.78	0.31	1.66
General mean	2.51	0.32	1.68	3.06	0.37	2.22

Table 2
Nutrient budgeting of major nutrients in green manuring crops

Treatment	*Nutrient budgeting kg ha^{-1}*					
	2013			*2014*		
	N	*P*	*K*	*N*	*P*	*K*
Green manuring crops						
G_1 - Sannhemp	103.12	18.44	76.62	133.85	21.28	102.16
G_2 - Dhaincha	152.48	18.90	121.24	162.34	20.13	143.43
G_3 - Cowpea	49.73	4.41	25.48	65.66	5.63	38.71
G_4 - Greengram	47.49	5.35	24.97	61.99	6.91	37.01
General mean	88.21	11.78	62.08	105.96	13.49	80.33

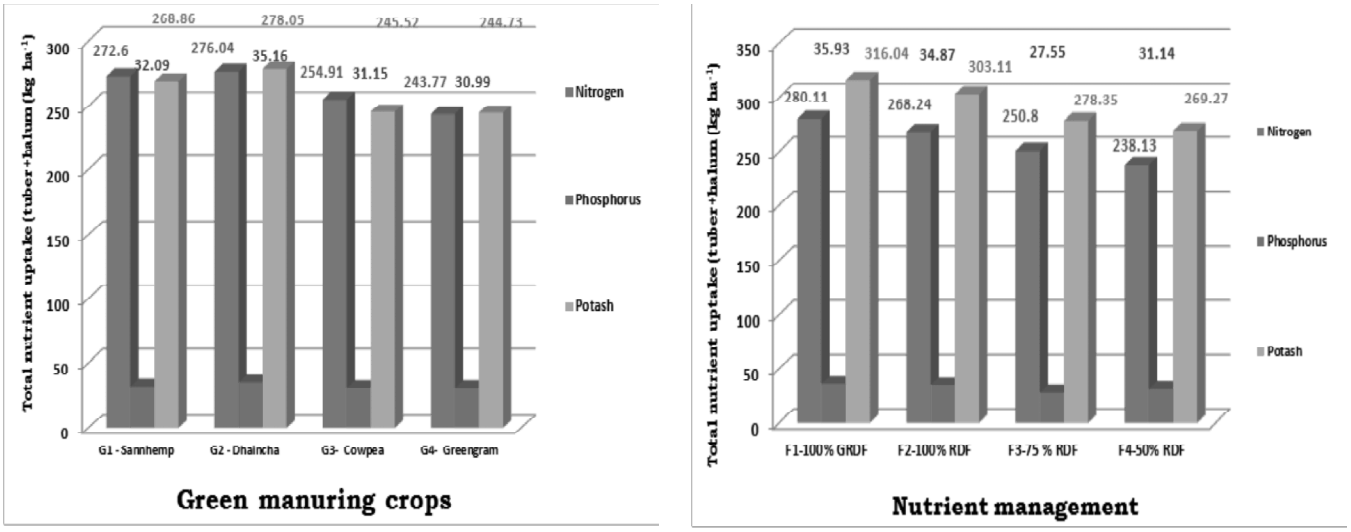

Figure 1: Nutrient uptake in potato as influenced by different treatments after harvest of potato (2013-14)

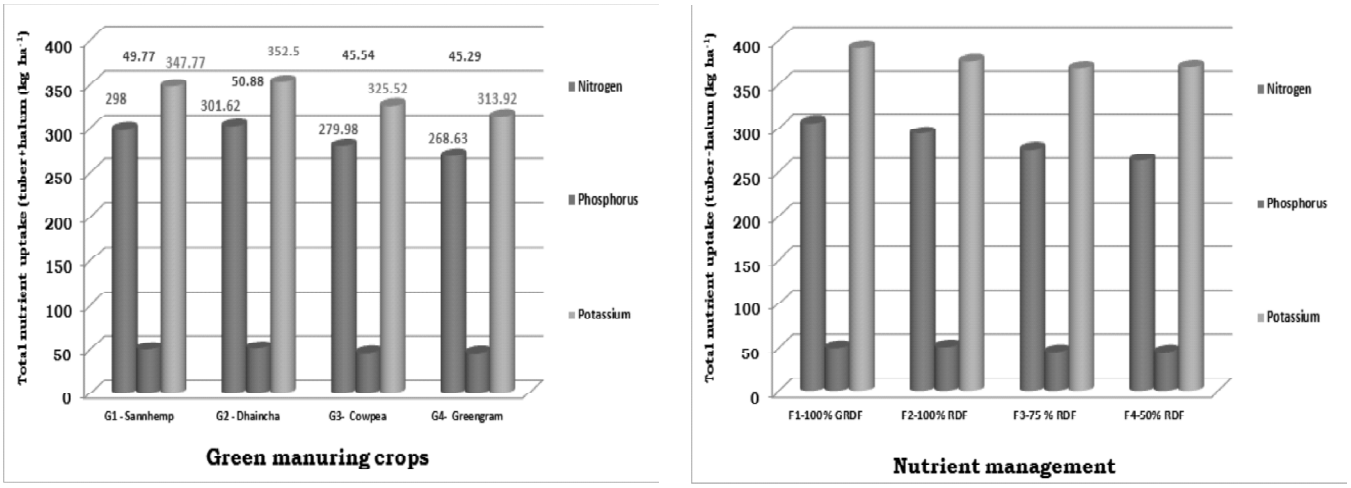

Figure 2: Nutrient uptake in potato as influenced by different treatments after harvest of potato (2014-15)

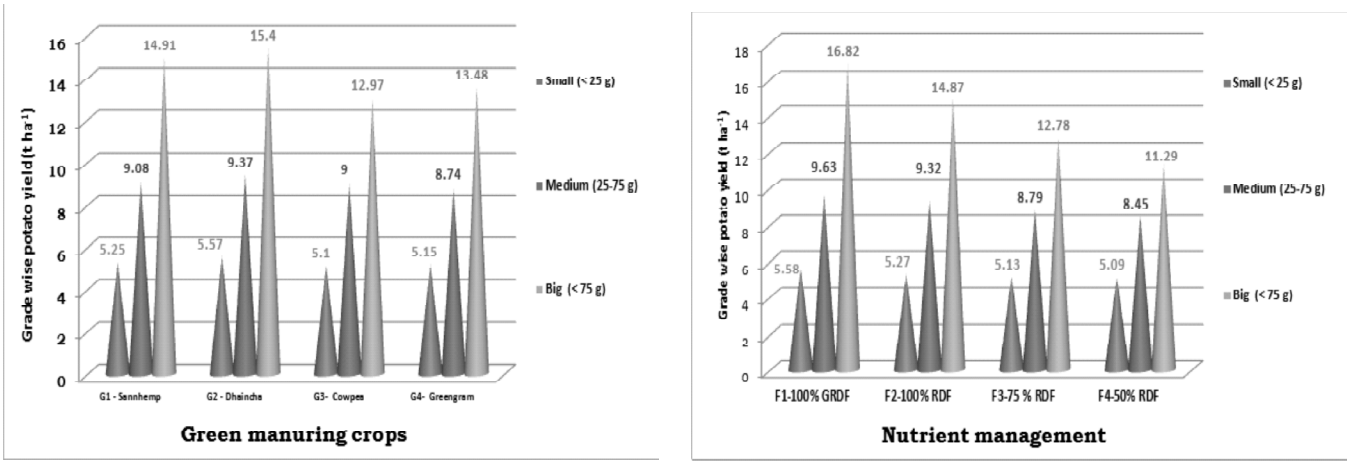

Figure 3: Grade wise potato yield (t ha^{-1}) as influenced by different treatments during 2013-14

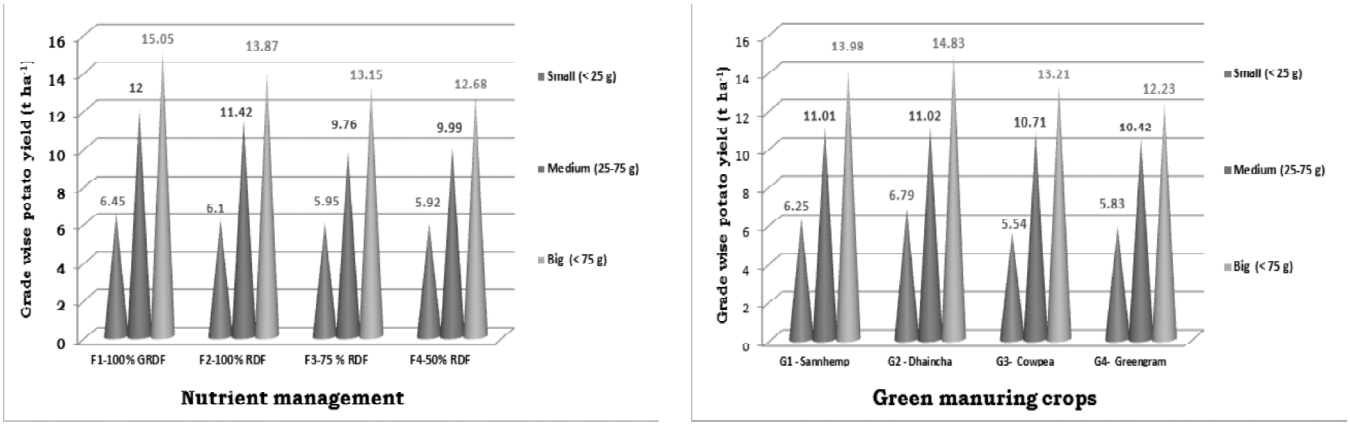

Figure 4: Grade wise potato yield (t ha^{-1}) as influenced by different treatments during 2014-15

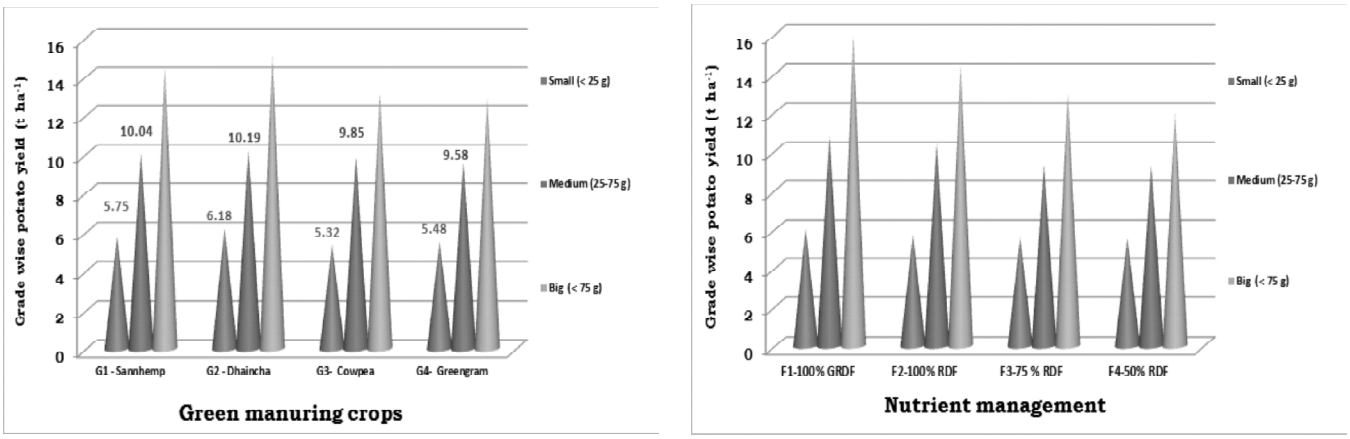

Figure 5: Grade wise potato yield (t ha^{-1}) as influenced by different treatments (pooled)

Table 3
Nutrient uptake of potato as influenced by different treatments after harvest of potato (2013-14)

Treatment	*Nutrient uptake (kg ha^{-1})*					
	Nitrogen		*Phosphorus*		*Potassium*	
	Tuber	*Haulm*	*Tuber*	*Haulm*	*Tuber*	*Haulm*
A. Green manuring crops						
G_1 - Sannhemp	269.76	2.78	30.99	1.10	263.31	5.55
G_2 - Dhaincha	273.24	2.84	33.99	1.17	272.36	5.69
G_3- Cowpea	252.38	2.51	30.19	0.96	241.01	4.51
G_4- Greengram	241.37	2.40	29.91	1.08	240.29	4.44
SEm ±	4.42	0.04	0.29	0.02	3.76	0.22
C.D. at 5 %	15.31	0.13	1.01	0.08	13.01	0.77
B. Nutrient management levels						
F_1 – 100% GRDF	277.36	2.75	34.71	1.22	263.71	5.81
F_2 – 100% RDF	265.63	2.61	33.71	1.16	256.14	5.47
F_3 – 75 % of RDF	248.15	2.65	26.50	1.05	247.22	5.30
F_4 – 50% of RDF	235.61	2.52	30.15	0.99	249.90	4.61
SEm ±	9.56	0.04	0.67	0.03	3.92	0.26
C.D. at 5 %	27.90	0.12	1.94	0.08	11.43	0.77
C. Interaction (AXB)	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
General mean	257.94	2.63	31.27	1.08	254.24	5.30

Table 4
Nutrient uptake in potato as influenced by different treatments after harvest of potato (2014-15)

Treatment	*Nutrient uptake (kg ha^{-1})*					
	Nitrogen		*Phosphorus*		*Potassium*	
	Tuber	*Haulm*	*Tuber*	*Haulm*	*Tuber*	*Haulm*
A. Green manuring crops						
G_1 - Sannhemp	294.30	3.70	47.7	2.07	382.79	7.78
G_2 - Dhaincha	297.85	3.77	48.71	2.17	394.89	7.96
G_3- Cowpea	276.61	3.37	43.63	1.91	352.98	6.94
G_4- Greengram	265.39	3.24	43.25	2.04	352.02	6.43
SEm ±	4.51	0.05	0.39	0.03	5.02	0.27
C.D. at 5 %	15.59	0.16	1.34	0.10	17.39	0.95
B. Nutrient management levels						
F_1 –100% GRDF	302.05	3.67	49.67	2.23	383.33	8.11
F_2 –100% RDF	290.10	3.54	48.33	2.14	368.87	7.69
F_3 –75 % of RDF	272.48	3.50	38.70	2.02	361.28	7.08
F_4 –50% of RDF	259.52	3.38	43.57	1.95	363.21	6.63
SEm ±	9.74	0.05	0.89	0.03	5.24	0.32
C.D. at 5 %	28.42	0.15	2.60	0.1	15.28	0.95
C. Interaction (AXB)	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
General mean	282.54	3.52	45.07	2.05	370.67	7.48

Table 5
Grade wise potato yield as influenced by different treatments

Treatment	*Grade wise potato yield (t ha^{-1})*								
	Small (< 25 g)			*Medium (25-75 g)*			*Big (< 75 g)*		
	2013-14	*2014-15*	*pooled*	*2013-14*	*2014-15*	*pooled*	*2013-14*	*2014-15*	*pooled*
A. Green manuring crops									
G_1 – Sannhemp	5.25	6.25	5.75	9.08	11.01	10.04	14.91	13.98	14.44
G_2 – Dhaincha	5.57	6.79	6.18	9.37	11.02	10.19	15.4	14.83	15.11
G_3- Cowpea	5.10	5.54	5.32	9.00	10.71	9.85	12.97	13.21	13.09
G_4- Greengram	5.15	5.83	5.48	8.74	10.42	9.58	13.48	12.23	12.85
SEm ±	0.04	0.08	0.06	0.10	0.07	0.86	0.27	0.44	0.36
C.D. at 5 %	0.15	0.28	0.22	0.33	0.24	0.29	0.94	1.51	1.23
B. Nutrient management levels									
F_1 –100% GRDF	5.58	6.45	6.01	9.63	12	10.82	16.82	15.05	15.94
F_2 –100% RDF	5.27	6.1	5.68	9.32	11.42	10.37	14.87	13.87	14.37
F_3 –75 % of RDF	5.13	5.95	5.54	8.79	9.76	9.27	12.78	13.15	12.97
F_4 – 50% of RDF	5.09	5.92	5.51	8.45	9.99	9.22	11.29	12.68	11.98
SEm ±	0.07	0.11	0.09	0.05	0.16	0.11	0.29	0.33	0.31
C.D. at 5 %	0.20	0.33	0.27	0.16	0.47	0.32	0.83	0.95	0.64
C. Interaction (AXB)	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
General mean	5.27	6.10	5.68	9.05	10.79	9.92	13.94	13.69	13.81

during tuber development stage and source sink relationship affected due to obtained Brian (2001), Khurna *et al.* (2003), Sincik *et al.* (2008), Carter *et al.* (2009) and Elsaid (*et al*.) 2014.

CONCLUSION

It may be concluded from the finding of this study based on the two years experimentation incorporation of dhaincha at 50% of flowering stage as a green manuring crop in *kharif* season and application of 100% general recommended dose of fertilizers (RDF-120:60:120 N P_2O_5 K_2O kg ha^{-1} + 20 tons of farm yard manure ha^{-1}) to potato in *rabi* season was found beneficial in terms of nutrient budgeting, nutrient uptake and gradewise potato yield.

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