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Inclusion of *in-situ* Green Manuring as One of the Important INM Practice to Improve the Growth and Economics of Potato (*Solanum tuberosum* L.)

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A B S T R A C T

A field experiment was done to assess the influence of INM practices with *in-situ* green manuring on growth and yield of potato at College of Agriculture, Hassan, UAS, Bangalore during *Kharif* 2013. The experiment was laid out in a factorial Randomized Complete Block Design (FRCBD) with three replications and twelve treatment combinations including 2 fertilizer levels (75 and 100% RDF), 3 compost levels (0, 12.5 and 25 t ha^{-1} compost) and *in-situ* green manuring with sunhemp and cowpea. The investigation revealed that among treatment combinations, 100% RDF + 25 t ha^{-1} compost + *in-situ* green manuring with cowpea recorded significantly higher plant height (73.1 cm), number of leaves (83.3 $plant^{-1}$), leaf area (7576 cm^2 $plant^{-1}$), leaf area index (6.3), leaf area duration (101.3 days) and total dry matter production (71.5 g $plant^{-1}$). The higher net returns and B:C ratio (Rs. 1,01,550 ha^{-1} and 2.58, respectively) was recorded in the treatment with 75% RDF+12.5 t ha^{-1} compost + *in-situ* green manuring with cowpea (T_4) followed by 100% RDF + 25 t ha^{-1} compost + *in-situ* green manuring with cowpea (T_{12}). Application 75% recommended dose of NPK with 12.5 t ha^{-1} compost and *in-situ* green manuring with cowpea recorded less reduction in the tuber yield with high net returns and B:C ratio and it is economically feasible for the potato cultivation by saving 25% fertilizer and 50% compost.

Introduction

Sustainable crop production depends upon the rational use of chemical fertilizers and pesticides along with organic manures for better soil health. Owing to the constant production of crops from the soil, the latter is being depleted gradually of its nitrogenous and other nutrients. An ordinary crop takes about 25 lb. of nitrogen (N) from an acre. It is, therefore, necessary to replenish the soil with the elements, which are removed by the crops year after year. Moreover, in recent years increasing fertilizer costs, and concern for sustainable soil productivity and ecological stability in relation to use of chemical fertilizers, have emerged as issues of vital concern. Furthermore, heavy reliance on chemical fertilizers tends to favour economically those farmers with large hectarage. These considerations have led to a renewed interest in the organic manures such as FYM, compost and green manures.

Green manuring - a practice of ancient origin, is defined as the use of undecomposed green plant material, grown in situ or cut and brought in for incorporation to improve soil productivity. Green manuring is, thus, a very useful soil-improving practice for building up soil fertility. First, it increases the soil fertility by the direct addition of N to the soil. Second, it improves the soil texture by the addition of humus or organic matter, which is essential for making the soil more productive. The addition of organic matter improves both heavy and sandy soils, as it has a binding effect on the loose particles of the sandy soils and makes the hard and heavy soils porous. Thus, it also increases the water-holding capacity of the soil. Besides, the conditions for increasing the number of useful bacteria in the soil are also improved (Meelu *et al.*, 2007).

Potato is an arable crop prefers loose and friable soil for its normal growth and development. Economic part (tubers) of the crop developing in the soil, maintenance of arable / friable soil condition is essential even up to maturity of the crop. Application of organic manures in huge quantities is essential to ensure optimal soil physical condition. In the present scenario of reduced animal population, deforestation etc., availability of organic manure has reduced considerably. In view of this as an alternative inclusion of green manures either in rotation or intercropping are possibly need to explore.

Green manures exhibited significant influence on potato by reduction of verticillium wilt, increased quality of potatoes, provided fertilizer replacement values of 50 to 120 pounds of nitrogen per acre, supressed nematodes, reduced early die, reduced weeds and needs of some herbicides (Brian, 2001)

Potato cultivation is one of the major sources of income to the local farmers in the study area. Nutrient management in potato production in this area is highly intensive, relying heavily on chemical fertilizers and apart from this, the area receives pre-monsoon showers. By taking advantage of pre-monsoon showers, the *in-situ* green manuring could be possible and successful. With the above background, the present investigation was carried out to assess the Inclusion of *in-situ* green manuring as one of the important INM practice to improve the growth and economics of potato.

Materials and Methods

The experiment was conducted at the college of agriculture, Hassan, UAS, Bangalore, Karnataka in *Kharif* 2013. The soil was neutral in reaction (pH 7.08) and organic carbon content (0.48%) was low. The soil test results of the experimental site reveal that soil is medium in nitrogen (330.5 kg ha^{-1}), phosphorus (53.3 kg ha^{-1}) and potassium (215.0 kg ha^{-1}). During the cropping season (June 2013 - September 2013), a total of 459.5 mm rainfall was received. The field experiment was laid out in a factorial Randomized Complete Block Design (RCBD) with three replications. There were 12 treatment combinations comprising of 2 fertilizer levels (75 and 100% RDF), 3 compost levels (0, 12.5 and 25 t ha^{-1} compost) and *in-situ* green manuring with sunhemp and cowpea were included in this study. The treatment combinations were T_1:75% recommended NPK + control + *in-situ* green manuring with sunhemp, T_2:75% recommended NPK + control + *in-situ* green manuring with cowpea, T_3:75% recommended NPK + 12.5 t ha^{-1} compost + *in-situ* green manuring with sunhemp, T_4:75%

recommended NPK + 12.5 t ha^{-1} compost + *in-situ* green manuring with cowpea, T_5:75% recommended NPK + 25 t ha^{-1} compost + *in-situ* green manuring with sunhemp, T_6:75% recommended NPK + 25 t ha^{-1} compost + *in-situ* green manuring with cowpea, T_7:100% recommended NPK + control + *in-situ* green manuring with sunhemp, T_8:100% recommended NPK + control + *in-situ* green manuring with cowpea, T_9:100% recommended NPK + 12.5 t ha^{-1} compost + *in-situ* green manuring with sunhemp, T_{10}:100% recommended NPK + 12.5 t ha^{-1} compost + *in-situ* green manuring with cowpea, T_{11}:100% recommended NPK + 25 t ha^{-1} compost + *in-situ* green manuring with sunhemp, T_{12}:100% recommended NPK + 25 t ha^{-1} compost + *in-situ* green manuring with cowpea.

After the harvest of fodder maize grown during *Rabi* season of 2012-2013 the land was prepared by using disc plough followed by passing cultivator to break the clods and to collect weeds and stubbles. Finally the land was levelled using a bullock drawn leveller. The plot size was 3.6 m × 3.2 m (11.52 m^2). *In-situ* green manure crops (cowpea and sunhemp) were sown in their respective plots and incorporated at 45 DAS. On an average cowpea and sunhemp added 22.5 and 13.7 t ha^{-1} biomass, respectively (Table 1). Calculated quantities of compost were incorporated into the soil in each plot 15 days before planting of potato for proper decomposition according to the treatments.

Seed tubers of KufriJyothi weighing approximately 30-40 grams were dipped in a solution of Dithane M-45 (2 g in one litre of water) for 20 minutes and dried in shade before planting to prevent the decay of seed tubers. After bringing the soil to fine tilth, furrows at 60 cm apart were formed and calculated quantities of recommended dose of 125:100:125 kg N, P_2O_5 and K_2O ha^{-1} were applied in the form of urea, diammonium phosphate and muriate of potash, respectively as per the treatments to the each plot and mixed well into the soil. The tubers were planted half way the ridge at a distance of 20 cm. Fifty per cent of the recommended nitrogen was applied at the time of planting and remaining fifty per cent was applied four weeks after planting as top dressing. Common irrigation was given to all the treatments during the dry spell using portable sprinkler. Totally 4 irrigations were scheduled during the cropping period.

Five plants were randomly selected in net plot and labelled. Observations on growth parameters were recorded using these plants. The cost of cultivation was computed by considering the present prices of inputs prevailed during their use for different treatments. Similarly, the ruling market price for potato was considered for calculating gross return. The cost of cultivation was deducted from gross returns to arrive at net profit per hectare. Benefit cost ratio was worked out by dividing the gross returns to the total cost of cultivation. The data pertaining to the experiment were subjected to statistical analysis suggested by Gomez and Gomez (1984) and results were compared.

Results and Discussion

Meteorological condition during cropping period

During the cropping season (June 2013 - September 2013), a total of 459.5 mm rainfall was received (Table 2). The average maximum air temperature of 30.1 °C in the month of September 2013 and minimum temperature of 18.7 °C during the month of June and September 2013 was recorded. The mean monthly relative humidity ranged from 80 per cent in May - June to 85 per cent in July - August.

The fluctuations in weather conditions truly reflected on expected yield. During *kharif* 2013, the crop experienced favourable weather condition during its growth. A total rainfall of 459.5 mm was received during the crop growth period, which was slightly less than the normal. Mean monthly maximum temperature and mean monthly minimum temperature were higher than their normal values. The actual maximum relative humidity was higher than the normal during the crop growth period.

Growth parameters

The growth components of potato significantly increased with increasing rates of RDF (Table 3). Among the fertilizer levels, 100% RDF recorded significantly taller plants (68.1 cm), higher number of leaves (70.7 plant^{-1}), leaf area (6159 cm^2 plant^{-1}), leaf area index (5.1), leaf area duration (84.3 days) and total dry matter production (54.2 g plant^{-1}) except number of shoots plant^{-1} compare to 75% RDF. Our results are in agreement with those of Riley (2000), Van delden (2001) and Mondal *et al.,* (2005) who reported that growth and growth components increased with higher fertilizer rate.

Application of higher level of compost at 25 t ha^{-1} recorded significantly higher plant height (70.6 cm), number of shoots plant^{-1} (3.8), number of leaves (76.2 plant^{-1}), leaf area (6945 cm^2 plant^{-1}), leaf area index (5.7), leaf area duration (93.9 days) and total dry matter production (63.6 g plant^{-1}) compare to no compost application. Application of compost improved the growth parameters probably due to improved soil physical condition and supply of macro and micro nutrients. These results are in line with the findings of Ashwini Kumar Sharma and Sarjeet Singh (2000) and Krishnamurthy *et al.*, (2002).

Table.1 Biomass added and nutrients content of green maures and compost

Particulars	Green manures		Compost
	cowpea	sunhemp	
N (%)	0.89	0.71	0.58
P_2O_5 (%)	0.15	0.12	0.43
K_2O (%)	0.58	0.51	0.97
Biomass added (t ha^{-1})	22.5	13.7	-

Table.2 Meteorological data of experimental site for the cropping period at College of Agriculture, Hassan

Month	Rainfall (mm)	Minimum temperature (ºC)	Maximum temperature (ºC)	Relative humidity (%)
June	162.0	18.7	29.4	81.5
July	61.5	21.3	28.1	84.7
August	122.0	23.1	29.0	83.8
September	114.0	18.7	30.1	82.7
Total	459.5			

Table.3 Growth parameters as influenced by INM practices with *in-situ* Green manuring in potato

Treatments	Plant height (cm)	No. of shoots plant^{-1}	No. of leaves plant^{-1}	Leaf area (cm^2)	LAI	LAD (days)	TDM (g plant^{-1})
Fertilizer level (F)							
F_1	65.0	3.2	63.6	5155	4.3	72.1	46.4
F_2	68.1	3.4	70.7	6159	5.1	84.3	54.2
S.Em.±	0.56	0.11	1.33	112	0.09	1.20	0.48
CD @ 5%	1.63	NS	3.91	330	0.27	3.53	1.40
Compost level (C)							
C_0	60.7	2.8	56.0	3619	3.0	53.8	34.0
C_1	68.3	3.4	69.3	6407	5.3	86.8	53.2
C_2	70.6	3.8	76.2	6945	5.7	93.9	63.6
S.Em.±	0.68	0.13	1.63	137	0.11	1.47	0.59
CD @ 5%	2.00	0.377	4.78	404	0.33	4.32	1.72
Green manures (G)							
G_1	65.1	3.2	64.6	5102	4.2	72.0	46.1
G_2	68.0	3.5	69.7	6212	5.1	84.4	54.5
S.Em.±	0.56	0.11	1.33	112	0.09	1.20	0.48
CD @ 5%	1.63	NS	3.91	330	0.27	3.53	1.40
Interaction (F×C×G)							
$F_1 \times C_0 \times G_1$	56.1	2.7	50.6	2679	2.2	39.5	26.0
$F_1 \times C_0 \times G_2$	59.9	2.9	53.6	3316	2.7	48.2	31.6
$F_1 \times C_1 \times G_1$	66.4	3.1	63.3	4827	4.0	72.0	45.0
$F_1 \times C_1 \times G_2$	69.8	3.6	73.6	7332	6.1	97.4	60.8
$F_1 \times C_2 \times G_1$	66.8	3.3	65.6	5411	4.5	76.8	49.4
$F_1 \times C_2 \times G_2$	71.0	3.8	75.0	7367	6.1	98.6	65.3
$F_2 \times C_0 \times G_1$	61.4	2.9	57.6	3951	3.2	59.5	37.2
$F_2 \times C_0 \times G_2$	65.5	2.9	62.0	4531	3.7	68.1	41.3
$F_2 \times C_1 \times G_1$	68.2	3.4	69.6	6317	5.2	85.1	50.8
$F_2 \times C_1 \times G_2$	68.8	3.5	70.6	7152	5.9	92.9	56.2
$F_2 \times C_2 \times G_1$	71.7	3.9	81.0	7425	6.1	99.0	68.1
$F_2 \times C_2 \times G_2$	73.1	4.1	83.3	7576	6.3	101.3	71.5
S.Em.±	1.36	0.26	3.27	275	0.23	2.95	1.17
CD @ 5%	NS	NS	NS	NS	NS	NS	3.44

F_1 - 75% RDF; F_2 - 100% RDF; C_0 - Control; C_1 - 12.5 t ha^{-1} compost; C_2 - 25 t ha^{-1}compost
G_1 – *in-situ* green manuring with sunhemp; G_2 – *in-situ* green manuring with cowpea
NS – Non significant

Table.4 Economics of in potato as influenced by INM practices with *in-situ* green manuring

Treatments	Tuber yield (t ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B: C
T_1-$F_1 \times C_0 \times G_1$	10.67	57500	106700	49200	1.85
T_2-$F_1 \times C_0 \times G_2$	11.16	57500	111600	54100	1.94
T_3-$F_1 \times C_1 \times G_1$	11.87	64250	118700	54450	1.84
T_4-$F_1 \times C_1 \times G_2$	16.58	64250	165800	101550	2.58
T_5-$F_1 \times C_2 \times G_1$	13.23	71000	132300	61300	1.86
T_6-$F_1 \times C_2 \times G_2$	16.80	71000	168000	97000	2.36
T_7-$F_2 \times C_0 \times G_1$	11.65	62000	116500	54500	1.87
T_8-$F_2 \times C_0 \times G_2$	11.72	62000	117200	55200	1.89
T_9-$F_2 \times C_1 \times G_1$	13.53	68750	135300	66550	1.96
T_{10}-$F_2 \times C_1 \times G_2$	15.06	68750	150600	81850	2.19
T_{11}-$F_2 \times C_2 \times G_1$	16.93	72500	169300	96800	2.33
T_{12}-$F_2 \times C_2 \times G_2$	17.26	72500	172600	100100	2.38

F_1 - 75% RDF; F_2 - 100% RDF; C_0 - Control; C_1 - 12.5 t ha^{-1} compost; C_2 - 25 t ha^{-1}compost
G_1 – *in-situ* green manuring with sunhemp; G_2 – *in-situ* green manuring with cowpea

Similarly *in-situ* green manuring with cowpea recorded significantly higher plant height (68.0 cm), number of leaves (69.7 $plant^{-1}$), leaf area (6212 cm^2 $plant^{-1}$), leaf area index (5.1), leaf area duration (84.4 days) and total dry matter production (54.5 g $plant^{-1}$) except number of shoots $plant^{-1}$ compare to *in-situ* green manuring with sunhemp.

These findings are in accordance with the results obtained by several researchers (Plotkin, 2000 and Christopher, 2014) who found that growth of potato after green manure crops were higher.

The interaction effect between fertilizer levels, compost levels and *in-situ* green manuring found to be non-significant.

Economics (Table 4)

The higher net returns and B:C ratio (Rs. 1,01,550 ha^{-1} and 2.58, respectively) was recorded in the treatment with 75% RDF+12.5 t ha^{-1} compost + *in-situ* green manuring with cowpea (T_4) followed by 100% RDF + 25 t ha^{-1} compost + *in-situ* green manuring with cowpea (T_{12}). The lower B: C ratio (1.84) was noticed in the treatment with 75% RDF + 12.5 t ha^{-1} compost + *in-situ* green manuring with sunhemp (T_3). This was mainly due to higher cost of cultivation accounted by additional price of fertilizer and compost.

Potato responds significantly to fertilizer, compost and green manure levels. Our results indicated that growth parameters of potato were significantly increased as fertilizer levels and compost levels increased also with *in-situ* green manuring of cowpea.

Increase in the dry matter production of potato in case of in-situ green manuring with cowpea was 18.2 per cent compared to sunhemp. Application 75% recommended dose of NPK with 12.5 t ha^{-1} compost and *in-situ* green manuring with cowpea recorded less reduction in the tuber yield with high net returns and B:C ratio and it is economically feasible for the potato cultivation by saving 25% fertilizer and 50% compost.

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