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Research Article

INFLUENCE OF INTEGRATED NUTRIENT MANAGEMENT PRACTICES WITH *IN-SITU* GREEN MANURING ON YIELD AND QUALITY OF POTATO (*Solanum tuberosum* L.)

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Abstract: A field experiment was conducted to assess the influence of integrated nutrient management 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 tuber weight (207.1 g plant^{-1}), number of tubers (7.2 plant^{-1}) tuber yield (17.26 t ha^{-1}), starch content (77.8%) and crude protein content (13.3%) at harvest. Application of 75% recommended dose of NPK with 12.5 t ha^{-1} compost and *in-situ* green manuring with cowpea recorded similar results but little less reduction in the tuber yield and also quality as well. So, it is feasible for the potato by saving 25% fertilizer and 50% compost.

Keywords: INM, *In-situ* green manuring, RDF, tuber yield, quality

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Introduction

Potato (*Solanum tuberosum* L.) is one of the most important food crops both in developed as well as developing countries. It has the maximum quantities of calories, vitamins, minerals and proteins per hectare per day than any other food crops in the tropics and subtropics, and it is considered as a nourishing and wholesome food. Potato production is in over 1.48 million hectares area with the production of 49.34 million tonnes and the average productivity of 33.3 tonnes hectare^{-1} [1]. It is a short duration crop and is heavily fertilized by farmers to get higher yield through organic and inorganic sources. This results into poor soil fertility, soil productivity and higher cost of production. There is a need for development of low input, sustainable and environment friendly agro-techniques in lieu of heavy input chemical based agro-techniques. One of the ways in this direction could be the use of organic manures including green manures [2]. 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 are crops grown during a normal cropping season and incorporated into the soil while still green. The principle of green manures has been known and used successfully by farmers for centuries. Modern agriculture is rediscovering the benefits of this practice. Adopting green manures into potato-cropping systems requires knowledgeable management of several crops. Producers generally do not want to devote an entire season for green manure production. Potatoes are a long season crop and large potato growing areas have relatively short growing seasons (90-120 days). These problems have been largely overcome and potato producers can use a green manure either as a spring or fall planted crop to improve the soil, reduce diseases and increase profitability [3] with the above background, the present investigation was carried out to assess the influence of INM practices with *in-situ* green manuring on yield and quality of potato.

Material 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 revealed that soil was 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 (FRCBD) 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 T1:75% recommended NPK + control + *in-situ* green manuring with sunhemp, T2:75% recommended NPK + control + *in-situ* green manuring with cowpea, T3:75% recommended NPK + 12.5 t ha^{-1} compost + *in-situ* green manuring with sunhemp, T4:75% recommended NPK + 12.5 t ha^{-1} compost + *in-situ* green manuring with cowpea, T5:75% recommended NPK + 25 t ha^{-1} compost + *in-situ* green manuring with sunhemp, T6:75% recommended NPK + 25 t ha^{-1} compost + *in-situ* green manuring with cowpea, T7:100% recommended NPK + control + *in-situ* green manuring with sunhemp, T8:100% recommended NPK + control + *in-situ* green manuring with cowpea, T9:100% recommended NPK + 12.5 t ha^{-1} compost + *in-situ* green manuring with sunhemp, T10:100% recommended NPK + 12.5 t ha^{-1}

Table-1 Yield parameters as influenced by INM practices with *in-situ* green manuring in potato

Treatments	Tuber weight plant^{-1} (g)	No. of tubers plant^{-1}	Tuber grading (t ha^{-1})				Tuber yield (t ha^{-1})
			D <25 g	C 25-50 g	B 50-75 g	A >75 g	
Fertilizer level (F)							
F_1	159.0	5.7	3.70	3.72	3.20	2.84	13.26
F_2	171.5	6.1	3.55	4.10	3.58	3.08	14.29
S.Em.±	1.20	0.07	0.04	0.08	0.05	0.04	0.10
CD @ 5%	3.48	0.21	0.11	0.23	0.15	0.13	0.29
Compost level (C)							
C_0	135.6	5.3	3.78	2.99	2.74	2.09	11.30
C_1	170.6	5.9	3.61	4.06	3.38	3.18	14.22
C_2	189.6	6.4	3.47	4.69	4.05	3.61	15.81
S.Em.±	1.47	0.09	0.05	0.10	0.06	0.05	0.12
CD @ 5%	4.26	0.26	0.14	0.28	0.19	0.15	0.35
Green manures (G)							
G_1	154.9	5.6	3.62	3.61	3.20	2.68	12.91
G_2	175.6	6.1	3.63	4.22	3.57	3.23	14.64
S.Em.±	1.20	0.07	0.04	0.08	0.05	0.04	0.10
CD @ 5%	3.48	0.21	NS	0.23	0.15	0.13	0.29
Interaction (F×C)							
S.Em.±	2.08	0.13	0.07	0.14	0.09	0.08	0.17
CD @ 5%	6.03	0.36	0.20	0.40	0.26	NS	0.50
Interaction (F×G)							
S.Em.±	1.70	0.10	0.06	0.11	0.07	0.06	0.14
CD @ 5%	4.92	0.30	NS	0.33	0.21	0.18	0.41
Interaction (C×G)							
S.Em.±	2.08	0.13	0.07	0.14	0.09	0.08	0.17
CD @ 5%	6.03	0.36	0.20	NS	0.26	0.22	0.503
Interaction (F×C×G)							
F_1×C_0×G_1	128.0	4.8	3.64	2.41	3.05	1.57	10.67
F_1×C_0×G_2	133.8	5.4	3.77	3.02	2.32	2.05	11.16
F_1×C_1×G_1	142.4	5.7	3.42	3.31	2.73	2.41	11.87
F_1×C_1×G_2	198.9	6.1	3.78	4.72	4.08	3.85	16.58
F_1×C_2×G_1	158.7	5.7	3.80	3.85	2.67	2.91	13.23
F_1×C_2×G_2	201.6	6.4	3.50	4.71	4.06	3.93	16.80
F_2×C_0×G_1	139.8	5.6	3.87	3.01	2.57	2.20	11.65
F_2×C_0×G_2	140.6	5.6	3.53	3.22	2.72	2.25	11.72
F_2×C_1×G_1	162.3	5.8	3.52	3.89	3.16	2.96	13.53
F_2×C_1×G_2	180.7	6.0	3.71	4.31	3.56	3.48	15.06
F_2×C_2×G_1	203.1	6.3	3.15	4.87	4.76	3.75	16.93
F_2×C_2×G_2	207.1	7.2	3.43	5.31	4.69	3.83	17.26
S.Em.±	2.94	0.18	0.10	0.19	0.13	0.11	0.24
CD @ 5%	NS	0.52	0.28	NS	0.37	0.31	NS

F_1-75% RDF; F_2-100% RDF; C0-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

compost + *in-situ* green manuring with cowpea, T11:100% recommended NPK + 25 t ha^{-1} compost + *in-situ* green manuring with sunhemp, T12:100% recommended NPK + 25 t ha^{-1} compost + *in-situ* green manuring with cowpea.

After the harvesting 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). 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 Kufri Jyothi 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 each plot and mixed well into the soil. The tubers were planted half way the ridge at a distance of 20 cm. Fifty percent of the recommended nitrogen was applied at the time of planting and remaining fifty percent 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 and yield parameters were recorded using these plants. Tubers obtained from the five plants selected at random were graded after harvest as large sized: A-grade (>75g), medium sized: B-grade (50-75g), small sized: C-grade (25-50g) and very small sized: D-grade (< 25g) based on weight of tubers and finally total yield was calculated. The starch content in tubers at harvest was estimated as per the procedure given for reducing sugars by somogy. Glucose was used as a standard. The amount of glucose equivalent was multiplied by 0.9 to get starch content [4] and it was expressed in percentage. The crude protein content was estimated by multiplying the percent nitrogen in tubers by the factor 6.25 and it was expressed in percentage. The data pertaining to the experiment was subjected to statistical analysis and results were compared.

Results and Discussion

Yield parameters

Based on the analysis of field data, yield and yield parameters differed statistically among the different factors [Table-1]. Application of 100% RDF recorded significantly higher tuber weight (171.5 g plant^{-1}), tuber number (6.1), tuber yield under A, B and C grades (3.08, 3.58 and 4.10 t ha^{-1}, respectively) and finally total tuber yield (14.29 t ha^{-1}) compare to application of 75% RDF. Our results agree with those of [5-7] who reported that yield and other yield components increased with higher fertilizer rate. In general, most of the yields attributing characters of potato were significantly augmented by compost as compared to no compost level. Application of higher level of compost at 25 t ha^{-1} recorded significantly higher tuber weight (189.6 g plant^{-1}), tuber number (6.4), tuber yield

under A, B and C grades (3.61, 4.05 and 4.69 t ha^{-1}, respectively) and total tuber yield (15.81 t ha^{-1}). Increase in the yield and yield components mainly attributed to increased availability of humic substances to act as plant growth regulators and promote growth [8]. *In-situ* green manuring was advantageous in terms of the biomass production similar results with other green manure species were found by [9]. Positive relationships between the diversity of plant species and biomass production have been reported in other ecosystems [10]. *In-situ* green manuring with cowpea recorded significantly higher tuber weight (175.6 g plant^{-1}), tuber number (6.1), tuber yield under A, B and C grades (3.23, 3.57 and 4.22 t ha^{-1}, respectively) and total tuber yield (14.64 t ha^{-1}) compare to *in-situ* green manuring with sunhemp. Significant decrease in the yield in case of sunhemp green manuring was might be due to poor biomass yield (average of 13.7 t ha^{-1}) compare to cowpea (average of 22.5 t ha^{-1}), as a result of this nutrient release and availability was more in case of cowpea which attributed to better yield and yield components than sunhemp.

Table-2 Quality parameters of potato as influenced by INM practices with *in-situ* green manuring in potato

Treatments	Starch (%)	Crude protein (%)
Fertilizer level (F)		
F_1	66.6	9.8
F_2	68.6	10.8
S.Em.±	1.44	0.29
CD @ 5%	NS	0.86
Compost level (C)		
C_0	59.9	8.1
C_1	67.9	10.7
C_2	75.0	12.2
S.Em.±	1.76	0.36
CD @ 5%	5.17	1.06
Green manures (G)		
G_1	65.2	9.7
G_2	70.0	10.8
S.Em.±	1.44	0.29
CD @ 5%	4.22	0.86
Interaction (F×C)		
S.Em.±	2.50	0.51
CD @ 5%	NS	NS
Interaction (F×G)		
S.Em.±	2.04	0.42
CD @ 5%	NS	NS
Interaction (C×G)		
S.Em.±	2.50	0.51
CD @ 5%	NS	NS
Interaction (F×C×G)		
$F_1C_0G_1$	58.3	7.5
$F_1C_0G_2$	59.6	7.5
$F_1C_1G_1$	62.7	9.7
$F_1C_1G_2$	74.0	11.5
$F_1C_2G_1$	69.0	11.0
$F_1C_2G_2$	76.1	11.9
$F_2C_0G_1$	60.5	8.0
$F_2C_0G_2$	61.2	9.3
$F_2C_1G_1$	63.7	10.0
$F_2C_1G_2$	71.3	11.6
$F_2C_2G_1$	77.0	12.4
$F_2C_2G_2$	77.8	13.3
S.Em.±	3.53	0.72
CD @ 5%	NS	NS

F_1-75% RDF; F_2-100% RDF; CO-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, S-Non significant

The interaction effect between fertilizer levels, compost levels and *in-situ* green manuring found to be non-significant except in case of number of tubers plant^{-1}, A and B grade tuber yield. In general combined effect of fertilizer, compost and green manures enhanced the tuber yield, because of once incorporated, the compost and green manures provides a pool of fresh organic matter and there are numerous examples showing that application of compost and green manures increases soil organic matter in comparison to treatments where inorganic fertilizers alone are applied. This organic matter provides food to soil microorganisms, encouraging an increase in numbers and activity which inturn results into better physical and chemical condition of the soil, ultimately results into loose and friable soil for the tuber development and enhanced the yield. These results are in line with the findings of [2,11-13].

Quality parameters

The quality parameters of potato significantly increased with increasing rates of RDF [Table-2]. Among the fertilizer levels, 100% RDF recorded significantly higher crude protein content (10.8%) compare to 75% RDF (9.8%). Whereas, starch content did not differ significantly among fertilizer levels. This result indicated that, application of fertilizers had direct influence on crude protein content than starch. Application of higher level of compost at 25 t ha^{-1} recorded significantly higher starch (75.0%) and protein (12.2%) content compare to no compost application (59.9% and 8.1% of starch and protein content, respectively). Similarly, *in-situ* green manuring with cowpea recorded significantly higher starch (70.0%) and protein (10.8%) content compare to *in-situ* green manuring with sunhemp (65.2% and 9.7% of starch and protein content, respectively). The interaction effect between fertilizer levels, compost levels and *in-situ* green manuring found to be non-significant. Combined application of fertilizer, compost and green manures (cowpea) enhances the accumulation of starch and crude protein in higher percentage. This is mainly because of complementary interaction between fertilizers, compost and green manure and also slow release of nutrients by green manure so that, nutrients are readily available at tuber development stage. These results are in confirmation with the findings of [7,14] in potato and [15] in maize crop.

Conclusion

Potato responds significantly to fertilizer, compost and green manure levels. Our results indicated that tuber yield and quality parameters significantly increased as fertilizer levels increased. Increase in the yield of potato in case of application of compost at 25 t ha^{-1} was 40% compare to no compost application. *In-situ* green manuring with cowpea recorded 13.4% of more yield compare to *in-situ* green manuring with sunhemp. Besides this, cowpea added 64.2% more biomass than sunhemp. Even there is a significant difference between 75%& 100% RDF and 12.5 and 25 t ha^{-1} of compost for both yield and quality, we can recommend 75% RDF along with 12.5 t ha^{-1} compost, because the reduction in the yield was to the tune of only 7.7 and 11.1 % (protein content by 10 % and 14 %, respectively), respectively compare to 100 % RDF and 25 t ha^{-1} compost, respectively. While in the interaction effect of combined application of 75 % RDF along with 12.5 t ha^{-1} compost and *in-situ* green manuring with cowpea recorded only 4.1% decrease in the yield compare to combined application of 100 % RDF along with 25 t ha^{-1} compost and *in-situ* green manuring with cowpea.

Application of research: Application of 75% RDF along with 12.5 t ha^{-1} compost and *in-situ* green manuring with cowpea can reduce the use of fertilizer by 25% and compost by 50% with less reduction in the yield, besides sustaining the soil fertility status.

Research Category: Green Manure and Nutrient management

Abbreviations: FRCBD: Randomized Complete Block Design with Factorial Concept

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