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Evaluation of different fertilizer coating material to increase Nitrogen use efficiency in potato (*Solanum tuberosum* L.)

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Abstract
A field experiment, entitled "Evaluation of different fertilizer coating materials to increase Nitrogen use efficiency in potato (*Solanum tuberosum* L.)" was conducted at the Research Farm of ICAR - Central Potato Research Station, Gwalior (M.P.) during *Rabi* season of 2015-16. The experiment was laid out in randomized block design with 12 treatments replicated three times. The results revealed that 100% RDF N coated with Neem cake 5% produced significantly higher plant height (50.20 cm), number of leaves/plant (80.13), stem/plant (5.00) at 60 DAP, however fresh (and dry weight of tuber (g)/plant, tuber number /plant, nitrogen use efficiency, NPK content in soil (kg/ha), NPK % in both tuber and haulm, NPK uptake (kg/ha) by crop, yield (tuber, haulm and biological in kg/plot as well as q/ha). The maximum net return (68.7 Rs.'000) and benefit: cost ratio (1.85) was obtained under100% RDF N coated with Neem cake 5%. Further application of 100% RDF N coated with pond soil (clay) 5% recorded higher net return (Rs. 45.6 Rs.'000). Therefore, 100% RDF N coated with Neem cake 5% followed by 100% RDF N coated with pond soil (clay) 5% are the most suitable coating material to increase N use efficiency in potato crop.

Keywords: coating, nitrogen use efficiency, potato

Introduction
Potato (*Solanum tuberosum* L.) is one of the most important food crop both in developed as well as in developing countries. Potato introduced in India in 17th century by Portuguese. 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 million hectares with the production of 44.3 million tonnes and the productivity is 21967 kg/ha (Anonymous, 2015) [1].

Nitrogen is a first limiting nutrient in potato production thus has a great influence on crop growth, tuber yield and its quality. The Indian soils are generally deficient in organic matter, hence, unable to release N at the rate required to maintain adequate supply to the growing plant. Urea, when applied to crop is vulnerable to losses from volatilization and leaching. Current methods also reduce nitrogen use efficiency (NUE) by plants which limit crop yields and, moreover, contribute towards environmental pollution in terms of hazardous gaseous emissions and water eutrophication. Excessive soil nutrients especially N, may promote a source sink imbalance, which can delay tuber initiation, plant maturity and tuber backing and promote excessive foliage growth at the expense of tuber yield. An approach that offsets pollution while also enhancing NUE is the use of controlled release urea (CRU) for which several methods and materials have been reported. The physical intromission of urea granules in an appropriate coating material is one such technique that produces controlled release coated urea (CRCU). The development of CRCU is a green technology that not only reduces nitrogen loss caused by volatilization and leaching, but also alters the kinetics of nitrogen release, which, in turn, provides nutrients to plants at a pace that is more compatible with their metabolic needs (Babar *et al.*, 2014) [2].

In view of the above facts, the present investigation will be conducted to optimize nitrogen use efficiency of potato through different fertilizer coating materials.

Materials and Methods

A field experiment was conducted during the *Rabi* season of 2015-16 at ICAR- Central Potato Research Station, Gwalior. 26º13' N latitude, 78º14' East longitude and 206 m above mean sea level are the geographical co-ordinates of experimental field, Gwalior. The soil was silty-clay-loam with pH 7.4 and EC 0.23 dS/m, being low in organic carbon (0.37%) and available nitrogen (165.93 kg/ha), medium in available phosphorus (20.35 kg/ha) and high in available potassium (395.20 kg/ha) and 1.28 g/m^3, 2.56 g/m^3 and 44.47 % in case of bulk density, particle density and water holding capacity, respectively. The experiment was laid out in randomized block design with 3 replications. There were 12 treatments, viz. T_1: Zero N, P_2O_5 and K_2O, T_2: Zero N with 100% RDF P_2O_5 and K_2O, T_3: 50% of RDF N, T_4: 100% RDF N, T_5: 100% RDF N coated with Neem cake 5%, T_6: 100% RDF N coated with Neem cake 10%, T_7: 100% RDF N coated with FYM 5%, T_8: 100% RDF N coated with FYM 10%, T_9: 100% RDF N coated with pond soil (clay) 5%, T_{10}: 100% RDF N coated with pond soil (clay) 10%, T_{11}: 100% RDF N mixed with Super absorbent (UPDT) 12.5 Kg/ha and T_{12}: 100% RDF N mixed with Super absorbent (UPDT) 25 Kg/ha.

The recommended dose of N, P_2O_5 and K_2O were taken as 180, 80 and 120 kg/ha for the crop. Nitrogen, phosphorus and potassium were applied in the form of urea, single super phosphate (SSP) and muriate of potash, respectively (MOP). Half dose of nitrogen and full doses of phosphorus and potassium were applied as basal dose at the time of planting, whereas remaining nitrogen was applied at time of earthing up. Different coating materials were applied according to the treatments. Cultural practices were followed as per standard recommendation to potato crop. Variety 'Kufri Jyoti' was used in the experiment. Prior to planting, the field was well layout and prepared as per the standard procedure and planting was done on 19th October, 2015. On the next day of planting, application of Metribuzin @ 500 g a.i./ha was applied in each treatment to control weeds. The earthing up was done at 24 days after planting to provide loose soils around the plants for proper development of tubers and also for the purpose of weed control and put soil near plant to reduce greening of tubers.

Chemical properties of soil viz., pH, EC, Organic carbon, NPK content (kg/ha) were determined before start of the experiment and on completion of the trial from different treatments to monitor the changes in soil chemical properties. NPK content (%) and uptake (kg/ha) were also determined in plant (Haulm and tuber) as per the standard methods after harvesting. Five potato plants were randomly sampled from the inner rows of each plot leaving the border rows. The sampled plants were carefully duged up, the roots thoroughly washed under running water, put in labeled envelop bags and taken to the laboratory where the growth and yield parameters were recorded. The plant samples were partitioned into various plant fractions and after sun drying sample were subjected to oven-drying at 62°C til a constant weight was attained. Completely dried samples were weighed and the Dry Matter (DM) content of different plant parts was measured and expressed in g/plant. Growth parameter at 60 DAP and yield attributes at 30, 60 DAP, maturity stage were recorded and yield at harvesting. Economics was worked out taking both variable and fixed costs into account. Data were analyzed as per standard procedure with 5% probability level. Nitrogen use efficiency (NUE) calculated as;

$$\text{NUE (\%)} = \frac{\text{Total N uptake (kg/ha) in fertilized plot - Total N uptake (kg/ha) in control plot}}{\text{N dose applied (kg/ha)}} \times 100$$

Results and Discussion

Growth parameters

Different coating materials caused a marked variation in growth parameters of potato. Significant incensement in growth parameter *viz*., plant height, number of leaves per plant and stem per plant had a direct relationship with different coating materials. All coating treatments significantly increased growth parameters over Zero N, P_2O_5 and K_2O. The maximum values of all these growth parameters were recorded with application of 100% RDF N coated with Neem cake 5% followed by 100% RDF N coated with pond soil (clay) 5% whereas, Zero N, P_2O_5 and K_2O recorded lowest value for all growth parameter. Application of 100% RDF N coated with Neem cake 5% recorded 50.20 cm, 80.33 and 5 value under plant height, no of leaves per plant and stem per plant, respectively. It may be due to availability of nutrient in balanced amount due to effect of coating resulting higher growth of plant resulting in higher plant height, leaves number and stem per plant.

Yield attributes

The factors which are directly responsible for ultimate tuber yield *viz.*, tuber number /plant, fresh and dry tuber weight/plant were augmented significant effect over Zero N, P_2O_5 and K_2O because of applied coating of different material. Application of 100% RDF N coated with Neem cake 5% recorded significant maximum value followed by 100% RDF N coated with pond soil (clay) 5% for all above yield attributing parameters at all the stage of crop growth whereas, Zero N, P_2O_5 and K_2O (absolute control) was with lowest value in all cases.

Significantly higher number of tuber was registered with treatment T_5 (100% RDF N coated with Neem cake 5%) as compare to rest of the treatments at all the stages of crop growth except T_7, T_9 and T_{10}.through which it was at par. The significantly lowest number of tuber was under treatment T_1 (Zero NPK).

The significantly higher value of yield attributes over control may be due to increased growth parameter, resulting in increased supply of all the essential plant nutrients with improved physico-chemical and biological properties of the soil. All these favourable conditions might have resulted in greater accumulation of carbohydrates, proteins and their translocation from source to the sink (reproductive organs) which, in turn, increased the yield attributing parameters.

Soil content

Application of 100% RDF N coated with Neem cake 5% resulted significant higher OC % (0.51 %) as compared to other treatments excepted 50% of RDF N and100% RDF N coated with Pond soil (clay) 10% (0.49 %) through which was on par. It could be due to dried plant parts incorporation into the soil and decomposition of crop roots during crop duration. Similar findings were also reported by Vasanthi and Kumarswamy (2000) [5], and Verma *et al.* (2005) [6].

Application of 100% RDF N coated with Neem cake 5% recorded higher NPK content (191.90, 27.8 and 386.3 kg/ha NPK, respectively) as compared to other treatments whereas lowest value was with Zero N, P_2O_5 and K_2O (167.8, 18 and 321.9 kg/ha NPK, respectively). It might be due to positive effect of coating on soil NPK contents.

Crop NPK content and uptake

Significant variation in content and uptake of NPK in tuber and haulm were observed due to effect of different coating treatments. Application of 100 % RDF N coated with Neem cake 5% recorded significantly higher value of content (%) as well as uptake of NPK by crop (haulm, tuber and total) as compared to other treatments. The maximum values were as: 105.9, 87.7, 193.6, 34.9, 17.3, 52.2, 117.6, 59, 176.6 kg/ha with haulm N uptake, tuber N uptake, total N uptake (crop), haulm P uptake, tuber P uptake, total P uptake (crop), haulm K uptake, tuber K uptake, total K uptake (crop), respectively. However, minimum value for contents and uptakes of NPK were under Zero N, P_2O_5 and K_2O. It may be due to positive effect of coating on NPK content and uptake of crop in respect to haulm and tuber.

Nitrogen use efficiency

NUE is an important parameter to judge the N uptake pattern of crop due to effect of different coating materials. Data related to NUE revealed that all treatments shown statistically significant effect on NUE compare to Zero N, P_2O_5 and K_2O. However, in this regard, 100% RDF N coated with Neem cake 5% gave higher NUE (60.70 %) as compare to others. It may be due to nitrification inhibition property of neem (Misra and Chhonkar, 1978) [3].

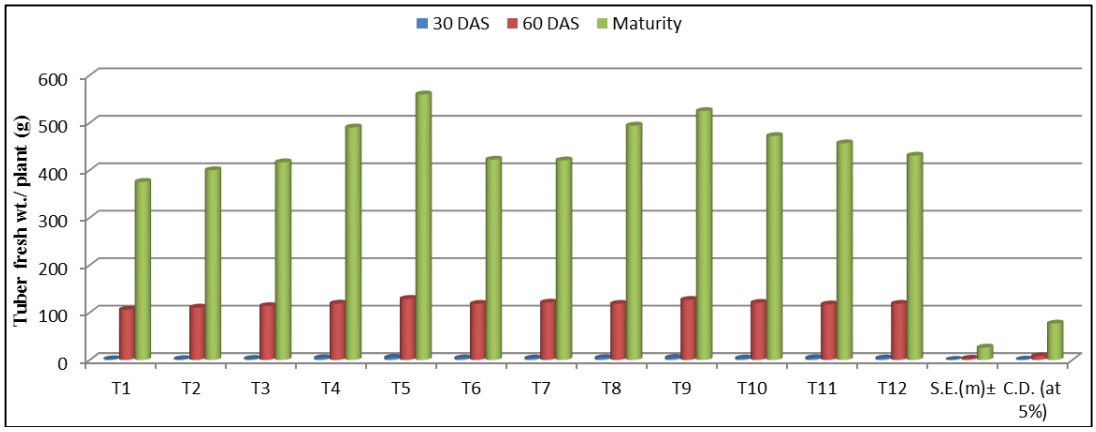

Fig 1: Effect of different coating materials on tuber fresh weight/plant (g)

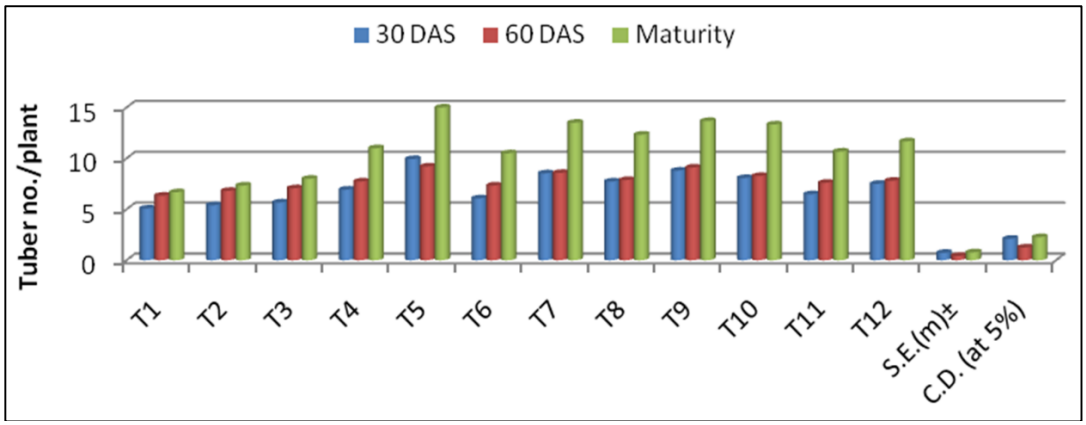

Fig 2: Effect of different coating materials on tuber number/plant

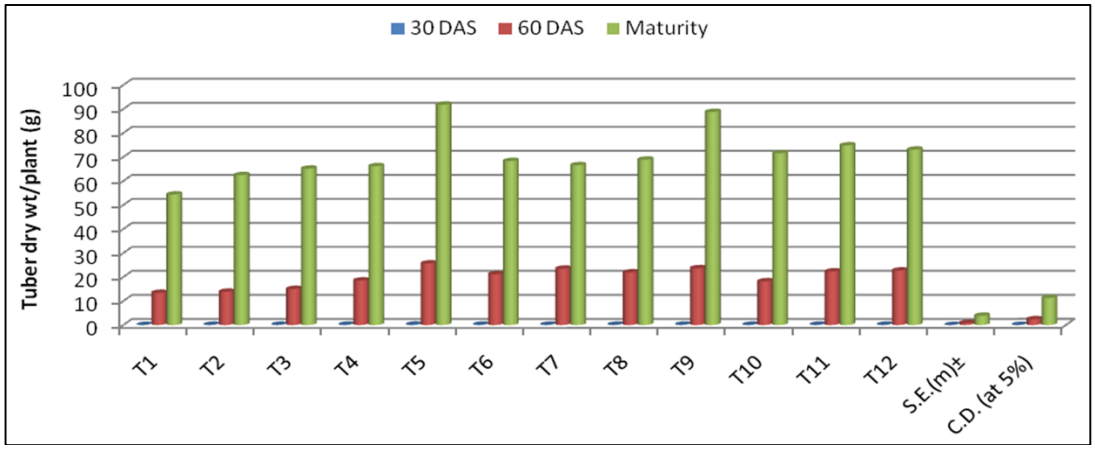

Fig 3: Effect of different coating materials on tuber dry weight/plant (g)

Table 1: Effect of different coating materials on growth parameter, economics, NUE and chemical property of soil

Treatments	Plant height (cm) at 60 DAP	Leaves/plant at 60 DAP	Stem/plant at 60 DAP	OC (%)	NPK content in soil (kg/ha)			CC (Rs' 000/ha)	Income (Rs' 000/ha)		B:C ratio	NUE (%)
					N	P	K		Gross	Net		
T_1	39.33	52.33	2.53	0.40	167.8	18.0	321.9	71.8	88.5	16.7	1.23	0.00
T_2	40.93	55.20	2.67	0.47	172.1	20.0	341.2	78.6	103.6	25.0	1.32	5.98
T_3	41.40	58.40	2.93	0.49	173.9	20.2	341.2	79.7	108.7	29.0	1.36	12.10
T_4	43.87	68.33	3.37	0.43	178.4	26.4	359.7	80.8	112.2	31.4	1.39	25.24
T_5	50.20	80.13	5.00	0.51	191.9	27.8	386.3	81.0	149.7	68.7	1.85	60.70
T_6	42.33	62.47	3.20	0.45	172.4	24.9	368.1	81.2	108.0	26.8	1.33	16.89
T_7	48.17	73.67	4.47	0.46	179.9	22.6	349.2	80.9	126.1	45.3	1.56	43.45
T_8	45.57	71.20	3.87	0.43	174.4	23.2	359.7	80.9	126.0	45.2	1.56	36.06
T_9	49.33	78.33	4.80	0.47	180.1	25.9	386.3	83.1	128.7	45.6	1.55	51.84
T_{10}	47.80	70.47	4.20	0.49	180.6	24.6	352.4	85.4	121.1	35.7	1.42	41.62
T_{11}	42.83	64.87	3.33	0.44	175.9	21.8	346.6	83.7	116.0	32.3	1.39	20.52
T_{12}	44.90	70.07	3.73	0.45	176.1	24.8	356.4	86.6	124.8	38.2	1.44	29.77
S.E.(m)±	1.21	3.81	0.29	0.02	4.0	1.5	12.9					1.98
C.D. (at5%)	3.56	11.18	0.85	0.06	11.6	4.3	38.0					5.80
Initial value				0.37	166	20	395					

CC: Cost of cultivation

Table 2: Effect of different coating materials on NPK uptake, content, yield and harvest index (%)

Treatment	NPK uptake (kg/ha)									NPK %						Yield t/ha			HI %
	N			P			K			N		P		K		H	T	Biological	
	H	T	Total	H	T	Total	H	T	Total	H	T	H	T	H	T				
T_1	42.2	42.2	84.3	10.1	8.4	18.6	44.1	30.4	74.5	2.33	2.16	0.24	0.26	1.27	1.48	12.38	14.76	27.14	54.79
T_2	47.6	47.6	95.1	12.2	9.3	21.5	48.3	33.4	81.7	2.39	2.18	0.25	0.27	1.30	1.52	16.66	17.26	33.92	48.37
T_3	55.4	50.7	106.1	14.3	10.2	24.4	52.0	34.3	86.3	2.45	2.20	0.26	0.27	1.32	1.53	17.18	18.12	35.30	49.76
T_4	73.4	56.4	129.8	21.2	13.5	34.7	73.6	40.2	113.7	2.62	2.30	0.28	0.29	1.46	1.54	19.05	18.71	37.76	52.05
T_5	105.9	87.7	193.6	34.9	17.3	52.2	117.6	59.0	176.6	2.69	2.73	0.35	0.32	1.51	1.59	21.82	24.96	46.77	53.28
T_6	62.5	52.3	114.7	16.5	11.4	27.8	58.2	36.5	94.8	2.33	2.27	0.27	0.28	1.45	1.55	22.83	18.01	40.83	44.08
T_7	88.1	74.5	162.6	29.3	16.0	45.3	108.2	50.4	158.6	2.66	2.48	0.31	0.31	1.49	1.58	19.62	21.02	40.64	51.77
T_8	83.9	65.3	149.3	25.5	14.4	39.9	82.2	45.5	127.7	2.64	2.40	0.29	0.29	1.47	1.55	17.53	21.01	38.53	54.51
T_9	96.0	81.6	177.6	32.1	16.2	48.3	114.5	55.4	169.9	2.68	2.55	0.34	0.31	1.36	1.58	19.77	21.44	41.21	51.98
T_{10}	87.3	72.0	159.3	27.3	15.2	42.5	96.9	47.2	144.1	2.65	2.46	0.30	0.30	1.48	1.56	18.98	20.18	39.16	51.36
T_{11}	66.2	55.1	121.3	18.6	12.9	31.4	65.4	38.4	103.8	2.62	2.29	0.28	0.28	1.46	1.53	18.42	19.33	37.75	52.97
T_{12}	75.6	62.4	137.9	23.1	13.6	36.7	78.5	42.6	121.1	2.63	2.37	0.29	0.29	1.47	1.55	17.28	20.80	38.09	54.62
S.E. (m)±	3.3	2.9	4.3	1.4	1.0	2.0	4.6	2.2	4.3	0.06	0.08	0.014	0.01	0.04	0.03	0.99	0.99	1.51	1.77
C.D. (at 5%)	9.6	8.5	12.7	4.1	2.9	6.0	13.4	6.3	12.7	0.18	0.24	0.04	0.03	0.13	0.08	2.90	2.90	4.42	5.19

H: Haulm, T: Tuber, CC: Cost of Cultivation (Rs.' 000/ha)

Yield

Tuber and haulm yield were significantly affected due to effect of different coating treatment. Application of 100% RDF N coated with Neem cake 5% recorded significant higher tuber yield24.96 t/ha) compared to other treatments on the other hand 100% RDF N coated with Neem cake 10% recorded significant higher haulm yield (22.83 t/ha) compared to other treatment except 100% RDF N coated with Neem cake 5% (21.82 t/ha) through which it was at par. It may be due to higher tuber wt/plant, higher no of stem/plant and supply of adequate amount of nutrients at different stages (Ranganathan and Selvaseelan 1997) [4].

Different coating treatments increased biological yield significantly over Zero N, P_2 O_5 and K_2O (27.14 t/ha). However, 100% RDF N coated with Neem cake 5% recorded significant higher biological yield (46.77 t/ha) compared to other treatments. It may be due to higher tuber and haulm yield.

Highest value of harvest index (54.62%) was recorded with 100% RDF N mixed with Super absorbent (UPDT) @ 25 Kg/ha. Further, 54.79, 54.51 and 53.28% were the order of higher harvest index under Zero N, P_2 O_5 and K_2O, 100% RDF N coated with FYM 10% and 100%RDF N coated with Neem cake 5%, respectively. It may be owing to higher tuber yield as compared to haulm yield on dry basis.

Economics

The maximum gross income was 149.7 Rs**'** 000/ha under application of 100% RDF N coated with Neem cake 5%. Zero N, P_2 O_5 and K_2O having lowest tuber yields and fetched the lesser gross income (88.5 Rs.' 000/ha). Rest of the treatments were in intermediate position for gross income ranging from 128.7 Rs.' 000/ha to 103.6 Rs' 000/ha.

The net income of different treatments followed the different trend due to diverse total cost of cultivation. 100% RDF N coated with Neem cake 5% fetched maximum (68.7 Rs' 000/ha) net income however Zero N, P_2 O_5 and K_2O fetched the minimum net income among all the treatments. Rests of the treatments were in intermediate position for net income ranging from 25.0 Rs' 000/ha to 45.6 Rs' 000/ha. Maximum value of B: C ratio was 1.85 under application of 100% RDF N coated with Neem cake 5% whereas minimum value was under Zero N, P_2O_5 and K_2O (1.23). Rest of the treatments were in intermediate position for B: C ratio ranging from 1.32 to 1.56.

Conclusion

On the basis of above findings, it is concluded that; application of 100% RDF N coated with Neem cake 5% followed by 100% RDF N coated with pond soil (clay) 5% recorded maximum N use efficiency, net income and B : C

ratio as well as also helpful to improving soil nutrient status among different coating treatments. Therefore, 100% RDF N coated with Neem cake 5% followed by 100% RDF N coated with pond soil (clay) 5% are the most suitable coating material to increase N use efficiency as well as obtaining higher yield.

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