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Effect of different levels and sources of nitrogen on growth and yield of Potato (*Solanum-tuberosum* L.)

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Abstract
A field experiment was conducted during the *Rabi* season of year 2019-20 on potato with variety *Kufri Ashoka* to test the RDN levels (0, 100, 125%) with two organic manures (poultry manure and goat manure) at Research farm of Tirhut college of Agriculture Dholi, Muzaffarpur Bihar. The treatment combination were i.e. T_1- control, T_2 – 100% RDN through fertilizer, T_3 – 125% RDN through fertilizer, T_4 – 100% RDN through poultry manure, T_5 – 100% RDN through goat manure, T_6 – 50% RDN though fertilizer + 50% RDN through poultry manure, T_7 – 50% RDN though fertilizer + 50% RDN through goat manure, T_8 – 75% RDN through fertilizer + 25% RDN though poultry manure, T_9 – 75% RDN through fertilizer + 25% RDN through goat manure, T_{10} – 100% RDN through fertilizer + 25% RDN through poultry manure, T_{11} – 100% RDN through fertilizer + 25% RDN through goat manure. The experiment was laid out in randomized block design and replicated thrice. The experimental site was sandy loam in texture, calcareous and slight alkaline in reaction (pH 8.31), low in organic carbon (0.40%), available N (212.55kg/ha), P_2O_5 (19.35kg/ha) and K_2O (118.12kg/ha), respectively.
All growth and yield parameter like per cent emergence, plant height, Number of shoots per plant, number of leaves per plant, dry matter accumulation, and bulking rate of tubers, yield attributes and yield were significantly influenced by the levels of RDN along with combination of poultry manure and goat manure. Among all treatments treatment T_{10} – 100% RDN through fertilizer + 25% RDN through poultry manure recorded higher per cent emergence (96.19), plant height (48.11cm), number of shoots per plant (6.29), number of leaves per plant (57.49), dry matter accumulation (70.68 g/plant), bulking rate of tubers (9.10g/plant/day), and tuber yield (274.75q/ha), total uptake of N (106.41kg/ha), P (24.51kg/ha) and K (122.88kg/ha) by crop and available N (223.86kg/ha), P_2O_5 (27.81kg/ha) and K_2O (135.14kg/ha) in soil after harvest of the crop which was statistically at par with treatments, T_3 (267.83q/ha) and T_{11} (272.48q/ha) and these three treatments were found to be superior over rest of the treatment.
In case of economic study, significantly higher B: C (3.30) was found under treatment T_{10}-100% RDN through fertilizer + 25% RDN through poultry manure and was at par with treatments T_3 -125% RDN through fertilizer and T_{11}- 100% RDN through fertilizer + 25% through goat manure.

Keywords: Levels of Nitrogen, Sources of nitrogen, potato, growth, yield, fertilizer, goat manure poultry manure, tuber yield and economics

Introduction
Potato is the fourth most important food crop in the world after rice, wheat and maize. Potato is a heavy feeder of nutrient and required a high amount of nitrogen, phosphorus and potassium. Nitrogen is the first limiting nutrient in potato production that greatly influences growth parameters, yield attributes and yield of crops. Likewise phosphorus, potassium and other nutrient elements are having equal importance in different crop production. Chemical fertilizers are the main source of nutrients in potato. However, the continuous application of chemical fertilizers causes nutritional imbalance and adverse effects on the physical, chemical and biological properties of soil. Thus an integrated approach of nutrient supply by chemical fertilizer along with organic manure is giving importance, especially in heavy feeder crops. Further considerable improvement in the quantity and quality of exhaustive and responsive crops like potato has been observed under the integrated use of organic and inorganic fertilizers as compared to the recommended dose of nutrients applied with chemical fertilizers (Baishya *et al*, 2012) [3].
Poultry manure increased organic matter content in soil and successively released the plant nutrient in available form for the utilization of the crops. Poultry manure supplies macro and micro nutrients in an available form to the growing plants (Magkos *et al.*, 2003) [6]. Poultry manure increases water holding capacity of the soil, improve drainage, increase soil aeration

And add some organic acids which dissolve soil nutrients and also act as ameliorating. Goat manure have physical and chemical properties that facilitate aggregation with soil particles especially finer soil particles like clay, modify soil structures and influence soil moisture regime there by encouraging rapid growth and development of crops. (Ag boola and Aiyelari, 2000) [1].

Study on the effect of FYM, oil cakes, vermicompost and inorganic fertilizer on the potato crop is sufficient available but the integration of poultry manure and goat manure with inorganic fertilizer especially nitrogen on growth and yield of potato is extremely lacking. Hence, an experiment was conducted keeping the facts insight to study the effect of nitrogen level, fertilizers and organic sources on the growth and yield potato crop.

Materials and Methods

A field experiment carried out during *Rabi* season of 2019-20 at Tirhut College of Agriculture research farm, Dholi (Muzaffarpur), Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur (Bihar). The soil of experimental plot was generally calcareous alluvium in nature and slightly alkaline in reaction. Soil contains a higher amount of free calcium carbonate ranging from 10-45% which was spread throughout the layer. Under chemical properties of soil, it has 0.40% organic carbon, available nitrogen 212.55kg/ha, available phosphorus 19.35kg/ha, available potassium 118.12kg/ha with pH 8.31 and electrical conductivity 0.37ds/m at 25^0C. The experiment was laid out in a randomized block design with three replication having eleven plots in each replication. The details of treatments was as T_1-control (no nutrient application), T_2-100% RDN through fertilizer, T_3- 125% RDN through fertilizer, T_4-100% RDN through poultry manure, T_5-100% RDN through goat manure. T_6- 50% RDN through fertilizer +50% RDN through poultry manure, T_7- 50% RDN through fertilizer +50% RDN through goat manure, T_8- 75% RDN through fertilizer +25% RDN through poultry manure, T_9- 75% RDN through fertilizer +25% RDN through goat manure, T_{10}- 100% RDN through fertilizer +25% RDN through poultry manure, T_{11}- 100% RDN through fertilizer +25% RDN though goat manure. The recommended dose of fertilizer was 150:90: 100kg N-P-K/ha. The whole amount of the recommended dose of P and K and half dose of N were applied as basal application and remaining half dose of N was given at 46 days after planting (DAP), respectively. Nitrogen was supply through urea. Phosphorous and potassium was applied through single super phosphate and muriate of potash, respectively. The poultry manure and goat manure was applied in the soil at 10 days before sowing of the crop. The poultry manure contained a relatively higher amount of nutrients (2.63% N, 2.04% P and 1.35% K) as compared to goat manure (1.91% N, 0.73% P and 1.36% K) during the winter season of 2019-20. Potato planting was done with variety *Kufri Ashoka* in specific planting arrangements as per treatments. The uniform size of tubers weighing 30-40 gram was taken for planting purpose. The all seed tubers were treated with a 0.2% solution of infill M-45 for 10 minutes to make it free from fungal infestation and planted after drying in shade. The sowing of tubers was done on the line just adjacent to the fertilizer line at 60cm between rows and 20cm between the plants. In each row, there were twenty tubers were planted in four-meter length. There were eight rows of potato in each experimental plot. It was followed by earthling up for covering the tubers at 20cm of height of the ridge. Post planting operations such as irrigation, weed management, earthling up, top dressing and plant protection measures were done as per right time and stage of potato crop. Dehaulming work was done 10 days before harvesting for good tuber development and maturity. Haulms were cut from the bottom leaving the rest portion as such under the ground for a minimum of 10 days. All requisite observations were taken from germination to harvest of crop (digging of tuber) and laboratory works too.

Table 1: Effect of levels and sources of nitrogen on growth and yield of potato crop

Treatment	Plant emergence at 30 DAP (%)	Plant height (cm) at harvest	No. of shoots/plant at harvest	No. of leaves/ plant at harvest	D.M (g/plant) at harvest	Bulking rate (g/day/plant) 60-75 DAP	No. of Tubers/plant	Weight of tubers/plant (g)	Tuber yield (q/ha)
T_1	91.21	28.27	3.12	21.22	41.10	4.01	3.90	144.30	109.89
T_2	93.95	41.01	5.15	31.50	60.15	7.38	7.29	251.11	237.89
T_3	95.12	45.72	6.01	36.62	67.42	8.61	8.72	281.75	267.83
T_4	93.31	36.46	3.76	22.32	56.60	5.93	5.59	189.52	208.84
T_5	92.51	36.01	3.47	21.12	54.11	5.64	4.20	166.90	205.62
T_6	93.92	41.06	4.84	29.07	60.57	6.81	6.07	209.47	235.83
T_7	93.71	40.01	4.76	28.27	57.62	6.42	5.56	199.16	234.18
T_8	94.52	43.17	5.58	34.46	62.37	8.04	7.68	259.91	242.62
T_9	93.70	42.05	5.62	33.41	61.43	7.91	7.63	256.29	239.87
T_{10}	96.19	48.11	6.29	38.71	70.68	9.10	9.09	292.30	274.75
T_{11}	95.19	47.02	6.12	37.23	68.56	8.89	8.83	284.92	272.48
S.Em (±)	3.26	1.66	0.18	0.97	2.40	0.30	0.31	7.82	8.48
CD (*P* =0.05)	NS	4.90	0.54	2.87	7.09	0.87	0.93	23.07	25.03
CV (%)	6.02	7.05	6.34	5.54	6.93	7.15	8.03	5.88	6.39

Treatment details

T_1 –Control (no nutrient); T_2 – 100% RDN through fertilizer; T_3 -125% RDN through fertilizer, T_4 -100% RDN through poultry manure; T_5 -100% RDN through goat manure; T_6 -50% RDN through fertilizer + 50% RDN through poultry manure; T_7 -50% RDN through fertilizer + 50% RDN through goat manure; T_8 -75% RDN through fertilizer + 25% RDN through poultry manure; T_9 -75% RDN through fertilizer + 25% through goat manure; T_{10} -100% RDN through fertilizer + 25% RDN through poultry manure; T_{11} -100% RDN though fertilizer + 25% RDN through goat manure.

Results and Discussion

Yield attributes and yield of potato crop

There was a non-significant impact of various treatments on per cent plant emergence at 30 DAP. However, the maximum plant emergence was recorded with 100% RDN through fertilizer and 25% RDN through poultry manure treatment (T_{10}) and the lowest plant emergence was observed with control (T_1). This was mainly due to fact potato tubers had enough food for nourishment of young sprouts emergence and the effect of applied nutrients estimated after their absorption through a well-developed root system (Kumar *et al.* 2013) [5]. The maximum plant height at various growth stages and at harvest (Table-1) were recorded with treatment T_{10}-100% RDN through fertilizers +25% RDN through poultry manure (48.11cm) which was at par to T_3-125% RDN through fertilizer (45.72cm) and T_{11}- 100% RDN through fertilizer +25% through goat manure. (47.02cm) while T_1- control showed poor plant height. The increment in plant height with an increase in fertilizer dosage coupled with organic manures could indicate that application of organic manure to the soil significantly enhanced nutrient availability and improved soil physical, chemical and biological property leading to a beneficial impact on the growth and development of crops as indicated by Yourtchi *et al.* (2013) [10].

Number of shoots/plant, dry matter accumulation per plant, bulking rate (g/day/plant) number of tubers/plant, weight of tuber/plant were influenced by the application of different treatments. These yield attributing characters were significantly higher under 100% RDN though fertilizer +25% RDN through poultry manure (T_{10}) and were at par to treatment T_3- 125% RDN through fertilizer and T_{11}-100% RDN though fertilizer +25% RDN through goat manure. It might be due to a better supply of water and nutrients through the organic and inorganic sources of nutrients with a beneficial effect on the physical, chemical and biological properties of soil (Meena *et al* 2016) [7].

A perusal of mean data indicated that there was an increase in the fresh yield of tubers at harvest with a subsequent increase in the dosage of nitrogen applied through the organic and inorganic sources The maximum potato tuber yield was obtained under T_{10} – 100% RDN through fertilizer + 25% RDN through poultry manure (274.75g/ha) which was found to be at par with treatment T_3 -125% RDN through fertilizer (267.83g/ha) and treatment T_{11} -100% RDN through fertilizer + 25% RDN through goat manure (272.48g/ha) while the minimum tuber yield was received under treatment T_1 – Control (109.89q/ha). Application of a higher dose of nitrogenous fertilizers along with organic manure (poultry and goat manure) might be due to strong influence on crop growth, tuber yield and its quality and also helps to increase tubulisation as well as tuber bulking rate that would have resulted in increased production. Application of organic manures in the soil improves nitrogen mineralization, plant absorption of phosphorus potassium and other mineral nutrients by promoting carbonic acid production. Application of organic manures either poultry manure or goat manure combined with chemical fertilizer could be attributed to their favourable effect on growth and yield components, like a higher number of stolon's per plant, plant height, dry matter production, shoots/plant, leaves/plant, bulking rate of the tubers and ultimately the tuber yield. This could be since the addition of organic manures along with fertilizer enhances the plants entire nutrient requirement that triggers vegetative growth, increase the total amount of radiation intercepted and photosynthesis rate during the tubulisation period. This clearly showed that the nutrients applied increased the quality and weight of tubers. The findings of Banjare (2012) [2] and Patel (2013) [8] supported the results of the present research.

Table 2: Response of different treatments on protein content, nutrient uptake, fertility statues of soil and economics of potato crop

Treatment	Protein content %	N-uptake (kg/ha)	P –uptake (kg/ha)	K –uptake (kg/ha)	pH	EC (ds/m)	Organic Carbon (%)	Organic matter (%)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	B:C Rs/Re
T_1	9.25	33.13	7.75	41.71	8.31	0.37	0.40	0.69	173.52	14.25	109.25	0.78
T_2	10.68	78.42	17.22	94.02	8.29	0.36	0.41	0.70	203.26	22.54	119.23	2.75
T_3	12.68	100.27	22.74	117.12	8.26	0.35	0.41	0.70	218.45	26.29	132.64	3.19
T_4	10.25	65.99	13.75	80.75	8.27	0.36	0.44	0.76	196.24	20.44	117.52	2.28
T_5	10.12	63.79	13.72	78.63	8.25	0.34	0.45	0.77	195.52	19.78	115.57	2.01
T_6	10.56	76.92	16.57	92.57	8.24	0.36	0.42	0.72	199.41	21.84	119.12	2.72
T_7	10.43	75.25	15.95	90.97	8.26	0.34	0.43	0.74	197.34	21.07	118.47	2.56
T_8	10.93	81.91	18.62	97.07	8.23	0.35	0.42	0.72	205.63	24.14	122.54	2.82
T_9	10.81	80.17	17.91	95.55	8.22	0.35	0.43	0.74	204.47	23.58	120.37	2.71
T_{10}	12.56	106.41	24.51	122.88	8.21	0.33	0.42	0.72	223.86	27.81	135.14	3.30
T_{11}	12.43	104.39	23.72	120.73	8.23	0.34	0.43	0.74	220.53	26.34	133.58	3.19
S.Em (±)	0.45	3.19	0.61	3.86	0.12	0.00	0.1	0.09	6.03	0.97	3.74	0.09
CD (*P* =0.05)	1.34	9.40	1.79	11.40	NS	NS	NS	NS	17.79	2.88	11.04	0.26
CV (%)	7.21	7.01	6.02	7.13	5.40	4.60	5.00	4.25	5.13	7.51	5.31	6.08

Treatment details

T_1 –Control (no nutrient); T_2 – 100% RDN through fertilizer; T_3 -125% RDN through fertilizer, T_4 -100% RDN through poultry manure; T_5 -100% RDN through goat manure; T_6 -50% RDN through fertilizer + 50% RDN through poultry manure; T_7 -50% RDN through fertilizer + 50% RDN through goat manure; T_8 -75% RDN through fertilizer + 25% RDN through poultry manure; T_9 -75% RDN through fertilizer + 25% through goat manure; T_{10} -100% RDN through fertilizer + 25% RDN through poultry manure; T_{11} -100% RDN though fertilizer + 25% RDN through goat manure.

Chemical analysis of plant and soil after harvest of potato crop

The present finding on the uptake of nitrogen, phosphorus and potassium in tuber and vine was influenced significantly with the application of different levels and sources of nitrogen. The highest total uptake of N, and K was observed with 100% RDN through fertilizer + 25% RDN through poultry manure (T_{10}) which was statistically at par with 125% RDN through

fertilizer (T_3) and 100% RDN through fertilizer + 25% RDN through goat manure (T_{11}) and the lowest uptake of N, P and K was observed with control (T_1). This might be due to narrow C: N ratio, continuous release of nutrients and release of organic acids by organic manure, which would have to improve the solubilisation of minerals and change of non-exchangeable to exchangeable form which led to direct and early absorption of N, P and K by the crops and also improve the amount of these nutrients in the soil (Sasani *et al*. 2003) [9].

Data obtained regarding protein content on a dry weight basis have shown a significant impact by different treatment (Table -2). The higher protein content recorded under T_{10} which was statistically at with T_3 and T_{11} and all these were significantly superior over T_1, T_2, T_4, T_5, T_6, T_7, T_8 and T_9. Increasing absorption of nitrogen and assimilation as ammonia with increasing nitrogen doses improved nitrogen content in tubers Kumar *et al*. (2009) [4].

Data obtained on organic carbon (%), organic matter (%), pH and electrical conductivity showed that there is a non-significant impact due to different treatment. The content of those parameters may significantly be raised by the continuous application of organic manures in huge amount. The maximum availability of nitrogen, phosphorus and potassium was found with 100% RDN through fertilizer + 25% RDN through poultry manure which was at par 125% RDN through fertilizer (T_3) and 100% RDN through fertilizer + 25% RDN through goat manure (T_{11}) while T_1 –Control plot showed minimum available NPK in soil. Organic acids released at the time of decomposition of organic manure increasing the availability of N P and K. The organic acids form a protective cover on sesquioxide which reduce the fixation of phosphate in soil and have a greater capacity to hold K in available form and reduces K- fixation due to interaction between organic matter and clay.

Benefit: Cost ratio

In the present investigation data on benefit –cost ratio as affected by different levels and sources (in organic and organic) of nitrogen on potato crop revealed that increasing level of the RDN with a combination of poultry manure and or goat manure significantly affected the benefit –cost ratio (Table -2). The maximum B:C (3.30) was fetched with T_{10} - 100% RDN through fertilizer + 25% RDN through poultry manure and this was at par to T_3 Treatment (3.19) and T_{11} treatment (3.19). The cost of cultivation was highest in organic + inorganic treatments as compared to inorganic alone. Kumar *et al*. (2009) [9] also reported similar result.

Conclusion

Hence, application of 100% RDN through fertilizer + 25% RDN through poultry manure or 100% RDN through fertilizer + 25% RDN through goat manure are suggested for sustainable potato crop production and maximum economic return as well as for enhancing the soil nutrient status under calcareous soil of north Bihar.

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