Fertilising for Sustainable Onion Production Systems

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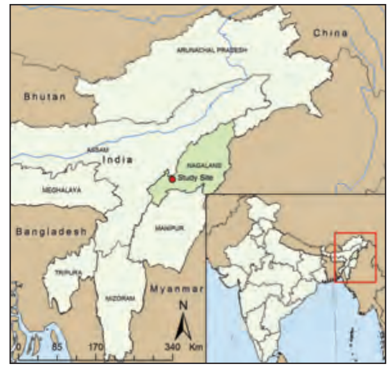
Studies evaluated straight versus combined applications of manures, fertilisers, and microbial biofertilisers with reference to onion bulb yield and soil nutrient balances. Given the good supply of quality manures, observations favored the combined application of inorganic fertilisers and manures over sole application of either nutrient source. Application of 50 to 75% of the fertiliser recommendation plus any microbial inoculant treatment failed to achieve a viable alternative.



Onion (*Allium cepa* L) is a highly nutrient-responsive crop. Conventional methods of fertilisation have undoubtedly helped in improving both bulb yield and quality. But lately, routine management practices in India appear to be incapable of maintaining yields over the long-term. The steady depletion of native soil fertility and the occurrence of multiple nutrient deficiencies in onion fields has led to the identification of nutrient management as a key factor limiting sustainable onion production (Sharma et al., 2003). Integrated nutrient management (INM) offers an effective strategy (Dimri and Singh, 2005; Santhi et al., 2005).

Although the use of manures as nutrient sources for vegetables is common, their effectiveness is potentially limited by nutrient release patterns that are often out of synchrony with crop demand, large variability in source quality and field distribution, and food safety. All of these issues have contributed to experimentation with alternative options. A gradual shift from using purely organic sources to introducing some proportion of inorganic fertilisation is gaining acceptance. This shift has formed the basis for INM, which could involve three nutrient sources: microbial inoculants or biofertilisers including azotobacter (Az), azospirillum (Azr), and phosphate solubilising bacteria (PSB), inorganic fertilisers, and manures. However, INM further prescribes that selected nutrient inputs be used judiciously to ensure optimum supply of all essential nutrients for sustained crop production. Most INM studies conducted with onion have lacked the experimental components required to link soil nutrient budgeting with bulb yield response.

This field experiment was carried out with two major objectives: 1) determine the magnitude and economic value of responses of onion to INM-based treatments, and 2) assess the nutrient uptake pattern to determine net changes in the soil nutrient balance sheet.

The experiment was conducted during the kharif (monsoon) seasons between 2007-09 at the experimental farm (25°45’43” N latitude - 93°53’04” E longitude) of the School of Agricultural Sciences and Rural Development (SASRD), Nagaland University, Medziphema, Nagaland to study fertilisation strategies for sustainable onion (var. Agrifound Dark Red) production. The experimental soil was classified as Typic Rhodustalf with a loam texture (58% sand, 20% silt, and 21% clay), pH 5.2 (1:2), high organic carbon (21.8 g/kg by Walkley and Black method), low available N (248 kg/ha by alkaline permanganate distillation method), low available P (11 kg P_2O_5/ha by Bray’s method), and low available K (178 kg K_2O/ha, ammonium acetate extractable) (Sparks, 1996).

Table 1 outlines 16 treatments that were replicated three

Abbreviations: N = nitrogen; P = phosphorus; K = potassium; SSP = single superphosphate; KCl = potassium chloride; RDF = recommended dose of fertilization; FYM = farmyard manure; PiM = pig manure; PM = poultry manure; Vm = vermicompost; CD = critical difference, equivalent to Least Significant Difference. INR = Indian rupee (USD 1 = approximately INR 44.41).

Combined application of inorganic fertilisers with organic manures offers better results in onion production in India.

Table 1. Response of different INM-based treatments on the onion bulb yield (fresh weight basis).

Treatments	----- Bulb yield, t/ha ----- 2007-08	2008-09	Mean
T_1 = Control	2.80	2.60	2.70
T_2 = Current recommendation (RDF)	3.32	3.80	3.56
T_3 = FYM	3.10	2.94	3.02
T_4 = Pig manure (PiM)	3.18	3.04	3.11
T_5 = Poultry manure (PM)	3.10	3.50	3.30
T_6 = Vermicompost (Vm)	3.60	3.46	3.53
T_7 = 50% RDF + 50% FYM	3.70	3.98	3.84
T_8 = 50% RDF + 50% PiM	3.50	3.80	3.65
T_9 = 50% RDF + 50% PM	3.40	3.96	3.68
T_{10} = 50% RDF + 50% Vm	3.91	4.19	4.00
T_{11} = 50% RDF + Az	2.81	3.01	2.91
T_{12} = 50% RDF + Azr	2.92	2.76	2.84
T_{13} = 50% RDF + PSB	2.72	2.92	2.82
T_{14} = 75% RDF + Az	2.98	3.04	3.01
T_{15} = 75% RDF + Azr	3.00	3.16	3.08
T_{16} = 75% RDF + PSB	3.18	3.06	3.12
CD (p = 0.05)	0.12	0.18	0.15

Table 2. Balance sheet for nutrient input and output for onion in response to INM treatments (mean of two seasons).

Treatments	Nutrient addition, kg/ha			Nutrient removal, kg/ha			Net balance, kg/ha		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
T_1	-	-	-	45 (1.68)[1]	25.2 (0.40)	32.4 (0.98)	-45	-25.2	-32.4
T_2	100	60	60	79 (2.22)	45.8 (0.57)	52.8 (1.24)	21	14.2	7.2
T_3	104	23	162	56 (1.86)	29.8 (0.44)	37.2 (1.02)	48	-6.8	124.8
T_4	109	18	95	61 (1.96)	36.6 (0.50)	44.4 (1.20)	48	-18.6	50.6
T_5	107	25	91	63 (1.90)	34.3 (0.44)	49.2 (1.12)	44	-9.3	41.8
T_6	102	18	74	75 (2.12)	41.2 (0.50)	48.0 (1.14)	27	-23.2	26
T_7	106	72	141	74 (1.92)	41.2 (0.46)	50.4 (1.10)	32	30.7	90.7
T_8	105	70	108	74 (2.02)	43.5 (0.51)	54.0 (1.24)	31	26.1	53.5
T_9	104	69	97	73 (1.98)	41.2 (0.48)	51.6 (1.16)	31	27.4	45.6
T_{10}	101	73	106	96 (2.40)	52.7 (0.58)	64.8 (1.34)	5	19.9	40.8
T_{11}	70	69	36	51 (1.76)	29.8 (0.44)	36.0 (1.02)	19	39.2	0
T_{12}	75	69	36	49 (1.72)	27.5 (0.43)	50.4 (1.88)	26	41.5	-14.4
T_{13}	50	114	36	50 (1.78)	29.8 (0.46)	37.2 (1.11)	0	84.2	-1.2
T_{14}	95	69	36	55 (1.82)	32.1 (0.46)	40.8 (1.14)	40	36.9	-4.8
T_{15}	100	69	36	56 (1.83)	34.3 (0.48)	43.2 (1.18)	44	34.7	-7.2
T_{16}	75	114	36	57 (1.84)	34.3 (0.49)	67.2 (0.18)	18	79.7	-31.2
CD ($p = 0.05$)	-	-	-	5.4 (0.12)	2.5 (0.03)	4.6 (0.16)	-	-	-

[1]Figures in parentheses represent nutrient concentration in %.

times and tested in a randomised complete block design. Full rates for the FYM (0.8% N, 0.08% P, 1.04% K), PiM (1.82% N, 0.14% P, 1.32% K), PM (2.14% N, 0.22% P, 1.52% K), and Vm (2.04% N, 0.15% P, 1.24% K) were designed to supply approximately the same N (100 kg N/ha) provided by the RDF treatment and were calculated to be 13 t, 6 t, 5 t, and 5 t/ha, respectively. The combined manure + fertiliser treatments were also designed to supply approximately 100 kg N/ha. Inorganic fertilisers sources were urea, single superphosphate (SSP), and potassium chloride (KCl). The anticipated nutrient to be added through the Az, Azr, and PSB biofertilisers was credited to the different treatments as 20 kg N, 25 kg N, and 20 kg P_2O_5/ha, respectively.

Each treatment received its entire dose (rate) of manure each year at the time of land preparation. The full dose of P, K, and half dose of N were applied each year at the time of planting and the remaining half dose of N was applied 30 days after planting. For the biofertilisers, the bulblets were dipped in treatment slurries at the rate of 10 g/kg bulblets and then dried under shade before planting. Experimental plots were treated with *Trichoderma* to minimise the incidence of damping-off disease. The bulblets were planted on raised beds during the first week of September and harvested in the first week of January in both the seasons.

The bulbs were harvested after more than 50% of leaves dropped down, and bulb fresh weight was measured. The bulbs were dried in shade, then chopped off and dried at 63 °C ± 2 °C, finely ground, and samples were digested in a 3:1 di-acid mixture of H_2SO_4 and $HClO_4$. In these acid extracts, nutrients were determined as per standard procedures including N by steam distillation using the micro-Kjeldahl method, P by colorimeter using the vanadomolybdophosphoric acid yellow color method, and K by flame photometer (Page et al., 1982). Nutrient budgets were calculated on the basis of nutrient inputs minus nutrient removal by onion bulbs.

Treatments supplying inorganic fertilisers and organic manures, either alone or in combination, generated a significant bulb yield response in both seasons over the control **(Table 1)**. Bulb yields were significantly correlated with bulb uptake of N ($r = 0.732$, $p = 0.01$), P ($r = 0.612$, $p = 0.01$), and K ($r = 0.405$, $p = 0.05$). Data averaged over the two seasons revealed VM to be the only manure source able to produce, by itself, bulb yields that were equivalent to those under the RDF. The best bulb yield responses were achieved with 50% RDF+Vm followed by 50% RDF+FYM. On the contrary, biofertilisers were unable to compensate for reduced application rates of inorganic fertiliser. The use of biofertilisers along with 50% or 75% RDF resulted in bulb yield averages that were at best equivalent to the poorer performing manure sources and in some cases were indistinguishable from the control. The positive performance of the reduced rate of inorganic

Scene at the National Research Center for Onion and Garlic in Pune, India.

Table 3. Economics of different INM-based treatments for Kharif onion production.

Treatments	[1]Cost, 000' INR/ha	[2]Benefit, 000' INR/ha	Net return, 000' INR/ha
T_1	2.50	54.00	51.50
T_2	10.28	71.20	60.92
T_3	20.00	60.40	40.40
T_4	25.00	62.20	37.20
T_5	20.00	66.00	46.00
T_6	11.00	70.60	59.60
T_7	15.14	76.80	61.66
T_8	17.64	73.00	55.36
T_9	10.64	73.60	62.96
T_{10}	15.94	80.00	64.86
T_{11}	8.14	58.20	50.06
T_{12}	8.14	56.80	48.66
T_{13}	8.64	56.40	47.76
T_{14}	9.46	60.02	50.56
T_{15}	9.46	61.60	52.14
T_{16}	9.96	62.40	52.44

[1]Cost of treatments based on price of urea at INR 5/kg, SSP at INR 8/kg, KCl at INR 40/kg, PiM, PM and Vm at INR 2/kg, FYM at INR 1/kg, Azr and Azo at INR 50/kg, and PSB cultures at INR 100/kg. It also includes operational charges covering labor charges for land preparation and two weedings at INR 5,000/ha.
[2]Benefit based on minimum farm rate of onion at INR 20/kg.

fertilisation plus either Vm or FYM does highlight the value of good manure sources as a supplement to inorganic fertilisers. Mineralisation of manures aids in soil nutrient buildup that in turn leads to improved nutrient availability to the growing crop (Singh et al., 2001).

Nutrient removal under the RDF treatment was hard to distinguish from that measured under any manure treatment **(Table 2)**. A comparison of the effect of combining inorganic fertilisers with manures versus their co-application with selected biofertilisers found significantly higher nutrient uptake with the former compared to the latter. As little as 25% of the RDF could not be replaced through biofertiliser supplementation, but up to 50% of the RDF could be effectively replaced with selected manures. The treatment with 50% RDF+Vm observed the highest average nutrient removal of 96-53-65 kg N-P_2O_5-K_2O/ha.

Considering the net nutrient balances presented, the current inorganic fertilisation recommendation maintained a surplus stock of nutrients over 2 years of study **(Table 2)**. All manure treatments developed P deficits, while the treatments with 50 to 75% RDF treatments used in combination with biofertilisers generated small to moderate K deficits. Treatments providing inorganic fertilisers and manure resulted in no deficit for any of the three primary nutrients.

Economic analysis highlighted that sole reliance on manures is not a cost-cutting measure, but favorable changes in soil quality likely compensate for additional costs per hectare through improved long-term nutrient turnover due to the organic amendments. However, net returns per treatment further substantiated the superiority of any combined fertiliser/manure application compared to a fertiliser or manure application at the rates examined **(Table 3)**.

Onion growers in this region often prefer organic manuring over inorganic fertilisation. As is indicated above, this preference is suggested to be a major cause of concern for the spread of multiple nutrient imbalances. Given the good supply of quality manures, our observations favored the combined application of inorganic fertilisers and manures over sole application of either nutrient source. This is a strategy capable of considering the sustainability of onion productivity as well as the preference to maintain a strong dependence on regional sources like FYM. BC-SA

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