International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(3): 3012-3017

Received: 09-03-2018
Accepted: 15-04-2018

Raja Rajeshwaran
Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

TH Sa
Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

K Arulmozhiselvan
Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Correspondence
TH Sa
Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Nitrogen release pattern from fertilizer pellet pack placed in soil

Raja Rajeshwaran, TH Sa and K Arulmozhiselvan

Abstract
Fertilizer Pellet Pack (FPP) is a design having fertilizer pellet encapsulated in a polymer coated paper pouch. In order to supply N to sugarcane, the slow release characteristics of different forms of FPP, having single and double layer of poly coat paper, were studied up to 10 months at fortnightly intervals of sampling. The treatments consisted 3 methods of composing FPP. In each FPP, fertilizer NPK nutrients were placed as urea, muriate of potash and P sources as DAP or SSP or both DAP + SSP. The FPP having 3450 mg of N was placed and incubated in 200 g of moist field soil. The results showed that the slow release of ammonium N resulted in FPP having NPK with P as either SSP or SSP + DAP in double layer. The release rate of ammonium N was slower (<0.6 %) during initial period of 90 days. The release of nitrate tremendously increased from the start day (12 mg) to a high value at 300 DOI (491 mg). Single layer FPP released significantly higher nitrate than single + double layer pack. Available N estimated in soil was the highest (1606 mg) in FPP having NPK with DAP as P source. Slow availability of N was noticed in FPP having single + double layer pellets (769 mg) with NPK containing P as SSP.

Keywords: nutrient release, nitrate N, ammonical N, available nitrogen

Introduction
Fertilizer Pellet Pack (FPP) is a design encompassing fertilizer pellet in a polymer coated paper encapsulation. In order to supply nitrogen to crop like sugarcane the slow release characteristicsof different forms of FPP have been studied particularly to have longer duration of nitrogen release. Fertilizer Pellet Pack having single layer and double layer were tested so as to make N release to suit stagewise N requirement of sugarcane. Commonly nitrogen fertilizers are applied as surface broadcast or band placement. By these methods the nitrogen use efficiency is low due to various losses. Fertilizer Pellet Pack having barrier layer of poly coat paper encapsulation was tested for its effectiveness in controlling N release. The release of N also expected to depend on the other ingredients added to N fertilizer while pelleting. In the present study N release was measured as ammonium N, nitrate N and available N. The effect of N release on soil electrical conductivity and soil pH also recorded. The period of study was up to 10 months at fortnightly intervals.

Sugarcane is a heavy feeder of nutrients and adequate manuring is therefore most essential for obtaining higher yields. An average crop of sugarcane yielding 100 t ha^{-1} removes 208 kg of N from the soil (DSD, 2013). The majority of N absorbed is accumulated during the grand growth period especially as total N in green tops followed by dry leaves and in the stalk (Rakkiyappan *et al*., 2007) [9]. For increasing the efficiency of N, placement of fertilizer at a depth in soil is effective. In a study, sugarcane was planted and fertilized in the furrows with 120 kg ha^{-1} of N as urea and under the experimental conditions the leached N represented 15 per cent of applied N. The losses of nitrate to groundwater ranged from <1 to 70 kg N $ha^{-1}crop^{-1}$in Australia, Brazil and Mauritius (Rasiah *et al*., 2010; Thorburn *et al.*, 2011; Webster *et al.*, 2012) [14, 13, 1].

Muthukrishnan *et al*. (2014) [7] studied the release pattern of N from FPP and found out that release of electrolytes was 12.4 per cent from FPP containing N as urea, P as DAP, and K as potash. It was also found out that addition of sago powder boosted the release of electrolytes, whereas addition of corn flour retarded the release of nutrient containing electrolyte.

By similar method the present study FPP containing urea as N source was aimed to release N in controlled way by the presence of potassium with either SSP or DAP as chief P sources.

The purpose of using different nutrient sources and poly coat paper encapsulation was to moderate N release particularly for a longer period matching to the N requirement of sugarcane crop. Yoganathan and Arulmozhiselvan (2016) [15] studied the N release characteristics of Nutripellet Pack and indicated that deep placement has recorded a greater N uptake under Nutripellet Pack placement. Possibly, the application of entire dose of urea in a single stroke along with diammonium phosphate and muriate of potash in the Nutripellet Pack resulted in the high N availability, which might be the responsible factor for enhanced N uptake.

Materials and Methods

The treatments of the study have3methods of composing FPPin the combination of phosphorous (P) sources from DAP or SSP or both DAP + SSP (Fig. 1) in combination with N and K in alternative encapsulation with either single layer or double layer.

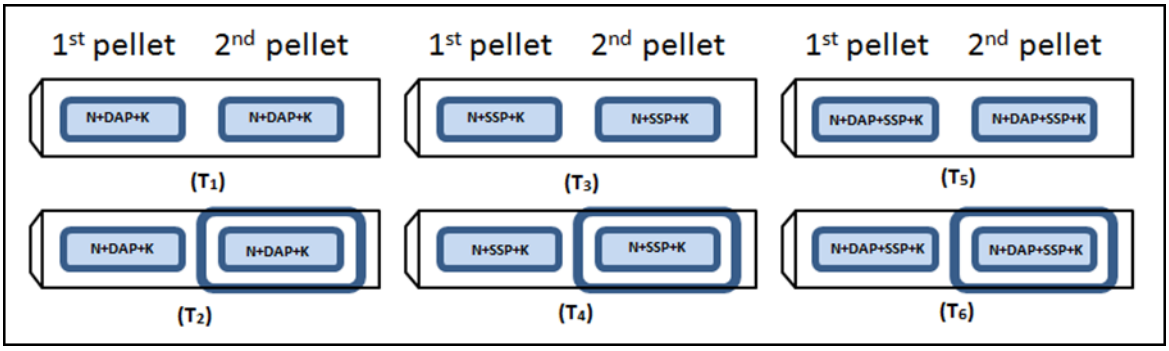


Fig 1: Diagrammatic indication of method of composing Fertilizer Pellet Pack

The symbolic indication of treatment details are as follows:

T_1 - NP_dK (S) + NP_dK (S); T_2 - NP_dK(S) + NP_dK (D); T_3 - NP_sK(S) + NP_sK (S); T_4 - NP_sK (S) + NP_sK (D); T_5 - $NP_{ds}K$(S) + $NP_{ds}K$ (S); T_6 - $NP_{ds}K$ (S) + $NP_{ds}K$ (D) T_7 – Control

P_d–P as DAP; P_s–P as SSP; P_{ds}– P as DAP + SSP; (S) –Single layer; (D) –Double layer.

The study was carried out in laboratory by incubating Fertilizer Pellet Pack (FPP) in moist soil. The experiment was carried out with sandy loam soil from Sathyamangalam soil series of taxonomic class Typic Ustropept, the pH of 7.70 and electrical conductivity of 0.28 dS m^{-1}. With the initial N (239.4 kg ha^{-1}), P (15.5 kg ha^{-1}), K (199 kg ha^{-1}). In the FPP, NPK fertilizer pelletwas encapsulated in degradable polymer coated paper with a thickness of 15 micron. In FPP, polymer has the role to permit the slow release of nutrients through minute spaces.

The polymer coated paper used was prepared by coating a normal paper with thin polyethylene sheet having short and broken polymers which helps in nutrient release and also leads to faster disintegration of the polymer material in soil. The degradation is expected to be more physical which is much hastened with exposure to soil heat due to sunlight. Normally, the degradation occurs approximately after 5-6 months. Until degradation, the material is intact acting as a rigid barrier layer around the fertilizer pellet.

It is expected that through the spaces, nutrients slowly dissolve out and then diffuse in soil water or move through capillary water. Thus, the slow release phenomenon is achieved by the polymer encapsulation and stands for the positive performance of FPP technique. In order to have long period of release up to 10 months or more, FPP having single or double layer is tested in the present study. Fertilizer Pellet Pack each containing 2 separate pellets (each 13 g) of fertilizer mixture appropriate to support NPK for sugarcane, containing NPK formed by different phosphorus sources of Diammonium phosphate / Single super phosphate / both along with urea and muriate of potash, and 0.5 % of refined wheat flour (Maida) as binding agent. The FPP was incubated in a 500 ml capacity plastic container in which 200 g of field soil was filledand closed with lid. Actually, the FPP was placed at the core of the soil, so that the soil was filling all around. This setup was maintained at 80% water holding capacity (WHC) throughout the experimental period of 10 months. The containers were arranged in completely randomized design (CRD) on a work table. Periodically samples were analyzed. Before sampling, the FPP kept within the soil was carefully removed and discarded. Then the remaining soil was mixed thoroughly and samples were collected and analyzed as moist soil. The result of analysis was expressed on dry weight basis. The amount of ammonium N, nitrate N and available N were estimated using standard procedures at fortnightly intervals. The release of N was expressed in mg per container. Thus, each container was incubated with FPP having 3450 mg of N. The rate of N release was computed and expressed as mg N released per day by averaging the values recorded for each sampling.

Results and Discussion

In the laboratory study conducted, the release of ammonium N, nitrate N and available N was recorded at fortnightly intervals. Out of 3450 mg of N placed in each FPP the release of N in soil was estimated.

Release of Ammonium N from Fertilizer Pellet Pack in soil

The release of ammonium was low, whereas release of nitrate N was high. The ammonium N released ranged from 6 mg at start day of placement (Table 1) which increased steadily reaching the highest value of 101 mg at 300 days of Incubation (DOI). Among the treatments FPP having single + single layer always recorded significantly high ammonium N release when compared to the FPP having single + double layer combination. The slow release of ammonium N was found in FPP having NPK pellet with either SSP (T_4) or both SSP + DAP (T_6) in double layer combination.

Release of ammonium N recorded from start day to 300 DOI was significant among treatments. The soil with FPP containing NPK with P as DAP in single + single layer combination (T_1) recorded the highest ammonium N (75.8 mg); which was significantly different from the same combination (67.0 mg) in single + double combination (T_2). The release of ammonium N in FPP containing P as DAP / SSP in single / double layer combination was moderate

varying from 52.4 to 59.0 mg (T_3 to T_6). The ammonium N of the control was lowest (9.5 mg).
In the study the ammonium N releasedwas low when compared to nitrate N which was about 6 times higher. This result is in agreement with the findings of earlier workers (Rochette *et al*., 2013; Huda *et al*., 2016) [11, 4].

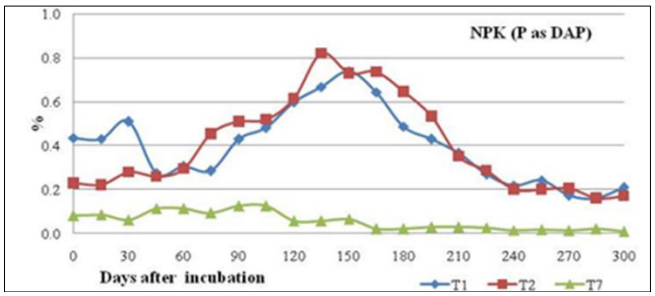
Table 1: Release of Ammonium N from Fertilizer Pellet Pack in soil (mg)

T. No.	Days of Incubation (DOI)																					
	0	**15**	**30**	**45**	**60**	**75**	**90**	**105**	**120**	**135**	**150**	**165**	**180**	**195**	**210**	**225**	**240**	**255**	**270**	**285**	**300**	**Mean**
T_1	6	10	30	30	35	39	48	51	53	57	71	84	96	103	112	119	121	128	131	133	136	75.8
T_2	6	11	17	16	18	22	31	35	38	52	60	70	82	100	107	116	119	122	126	128	131	67.0
T_3	6	7	11	18	27	28	30	40	44	53	57	58	72	74	79	89	93	98	101	103	105	56.8
T_4	6	6	10	16	16	22	24	21	35	40	56	56	65	71	76	85	90	93	96	98	100	51.5
T_5	6	12	20	11	11	24	25	30	35	38	50	54	75	85	95	103	105	111	115	116	119	59.0
T_6	6	9	11	7	11	13	16	18	24	35	44	46	65	76	88	96	102	104	108	110	112	52.4
T_7	6	8	9	9	10	12	11	16	10	8	12	12	9	8	9	10	8	8	8	8	9	9.5
Mean	6.0	9.0	15.4	15.3	18.3	22.9	26.4	30.1	34.1	40.4	50.0	54.3	66.3	73.9	80.9	88.3	91.1	94.9	97.9	99.4	101.7	
			SED		CD				SED		CD			SED		CD						
	T		3.36		6.63		P		11.48		11.48		T x P	11.48		11.48						

Fertilizer N placed in each FPP = 3450 mg.

Release rate of Nitrogen

Out of 3450 mg of N contained in FPP, the ammonium N (Fig. 1) released was calculated and expressed as release rate as per cent release day^{-1}. The release rate of ammonium N was slower (< 0.6 %) during initial period of 90 days. Thereafter high rate of ammonium N release (about 0.8 %) was noted in FPP having NPK with P as either DAP or DAP + SSP during 150 to 180 DOI. Whereas during the same period, in FPP having NPK with SSP the release of ammonium N was reduced. The rate of release of ammonium N subsided (< 0.4 %) after 180 DOI. In the case of FPP having NPK with P as SSP the release of ammonium N was moderate (about 0.4%) indicating the slow release characteristic of SSP combination with urea and MOP during the 90 to 180 DOI (Figure 1).
Similar trend was also observed by Mofijul *et al*. (2018) [6] who reported that in aerobic rice high NH_3 volatilization losses were occurred in first top dressing in prilled urea (about 2 kg ha^{-1})?,when compared to deep placement of urea briquette (<1 kg ha^{-1})?. In second and third topdressing also, ammonia losses in prilled urea was high (about 1 kg ha^{-1})?, and in urea briquette it was low (<0.25 kg ha^{-1}). The results indicated that with crop growth losses by ammonia volatilization was reduced, losses were always high with surface applied prilled urea, and losses were very low with deep placed urea briquette. Nieder *et al.*, (2011), reported that in a field experiment where sugarcane was grown, sandy texture of soil promoted ammonium release into the soil water easily and thus increased ammonia volatilization loss, whereas deep placement of urea briquettes saved N.



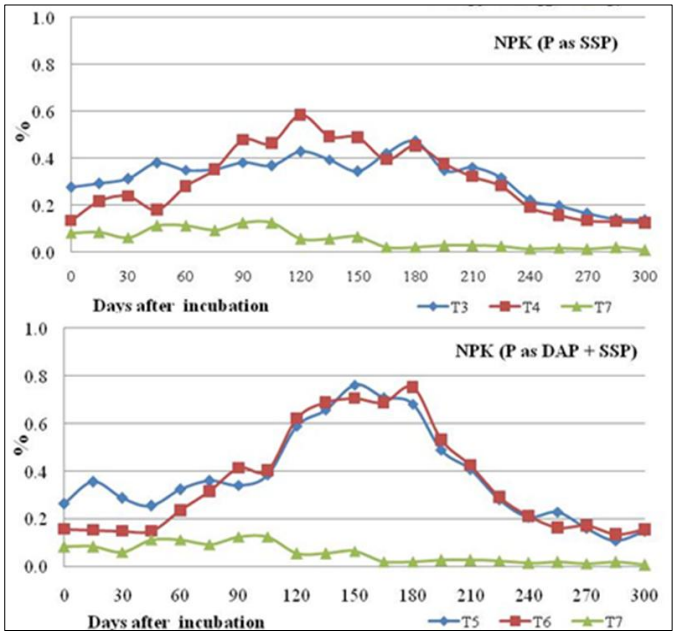


Fig 1: Release rate of Ammonium N in soil from Fertilizer Pellet Pack (%)

Release of nitrate N from Fertilizer Pellet Pack in soil

With the placement of FPP, the release of nitrate (Table 2.) tremendously increased from the start day (12 mg) to a high value at 300 DOI (491 mg). Among the FPP treatments the highest release was noted from fertilizer pellet composed with NPK having DAP (397 - 429 mg) as P source (T_1 and T_2). Single layer pack released significantly higher nitrate than single+double layer pack. Slow release characteristic was much noticed in FPP having single + double layer in the presence of NPK having SSP as P source (266 mg in T_4). With advancement of DOI the nitrate release increased steeply up to 120 to 150 DOI, thereafter nitrate release was reduced.
Similar pattern of nitrate release was observed by Libby *et al*. (2018) [5], where the nitrate concentration at the start day was 80 mg and it followed a quadratic pattern to reach 140 mg at the end of the experiment.

Table 2. Release of nitrate N from Fertilizer Pellet Pack in soil (mg)

T. No.	Days after Incubation																					
	0	**15**	**30**	**45**	**60**	**75**	**90**	**105**	**120**	**135**	**150**	**165**	**180**	**195**	**210**	**225**	**240**	**255**	**270**	**285**	**300**	**Mean**
T_1	12	13	91	137	264	280	354	485	494	502	518	531	540	544	547	574	614	621	625	628	633	429
T_2	12	8	64	128	238	278	300	307	400	472	501	523	537	542	544	551	573	585	590	594	599	397
T_3	12	9	9	102	110	123	96	152	166	205	250	368	418	463	500	506	528	537	540	545	546	295
T_4	12	10	6	14	48	55	67	75	140	184	229	331	390	438	472	503	513	519	522	526	529	266
T_5	12	15	16	22	49	66	84	154	225	363	481	489	518	523	531	532	539	545	550	558	560	325
T_6	12	10	14	15	15	57	58	127	191	231	332	407	500	503	524	531	538	543	548	550	556	298
T_7	12	14	20	16	15	14	16	16	15	11	12	14	15	15	15	16	16	15	15	14	16	15
Mean	12	11	31	62	106	125	139	188	233	281	332	380	417	433	448	459	474	481	484	488	491	

		SED	CD		SED	CD		SED	CD
	T	6.33	12.50	P	10.96	21.65	T x P	28.99	57.28

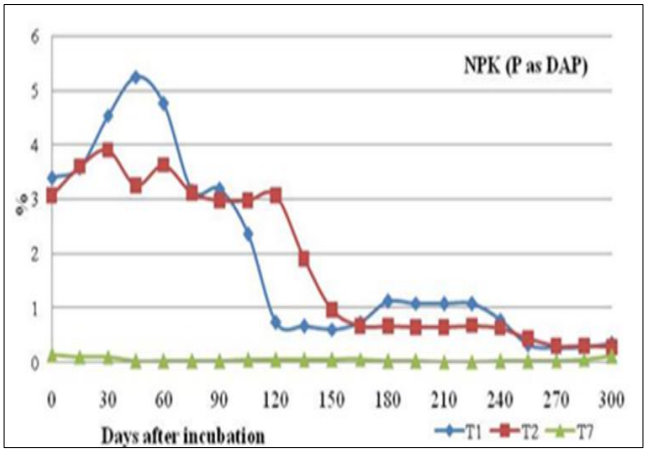
Fertilizer N placed in each FPP = 3450 mg.

Release rate of Nitrate N

Unlike the release pattern exhibited for ammonium N (Fig. 2), the release rate of nitrate N was found to be initially high (>5%) in FPP having NPK with P as DAP. Further the highest increase was also observed at 60 DOI in single + single layer combination. A steep increase was similarly noted in the FPP having NPK with P as DAP + SSP after 30 to 90 DOI then it fell down up to 200 DOI. A gradual decrease below 4 per cent was observed after 100 DOI and maintained thereafter till 200 DOI in the FPP having NPK with SSP.

The pattern of release of nitrate N from the fertilizer pellet having SSP, and DAP + SSP as P source along with N and K sources was found to be coinciding with the experimental results of Armour *et al*. (2013) [1] where the concentration of nitrate was low at the initial stage (43 mg), then went to the high level (102 mg) and finally again decreased (43 mg). This was attributed to denitrification processes that were insufficient to reduce N loads to a low level in the process of N transformation (Connor *et al*., 2012) [2].

For fertilization to sugarcane crop in the field, the high release recorded in the present study after 60 DOI coincides with the tillering and grand growth phase of the crop. This is matching up with the sugarcane crop indicating that Fertilizer pellet having SSP as P source combination would be suitable in supporting the sugarcane growth in the field better than any other combinations.



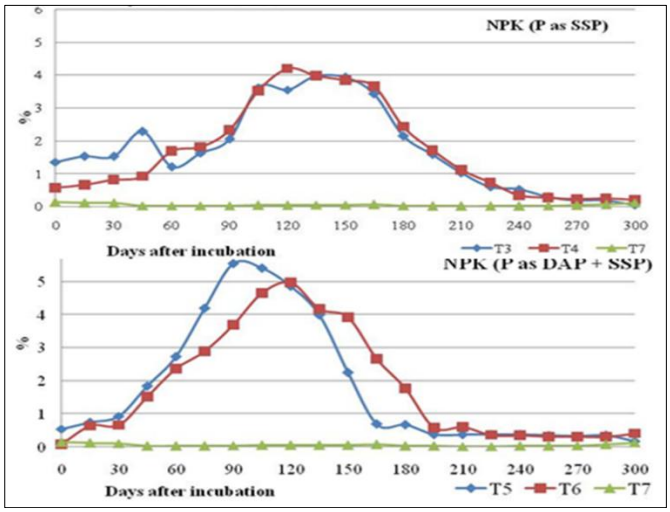


Fig 2: Release rate of Nitrate N in soil from Fertilizer Pellet Pack (%)

Release of available N from Fertilizer Pellet Pack in soil

With the advancement of days available N (Table 3) increased from 29 mg at start day to 1778 mg at 300 DOI. Available N estimated in soil placed with FPP was the highest (1606 mg) in FPP having NPK with DAP as P source. Slow availability of N was noticed in FPP having single + double layer pellets (769 mg) with NPK containing P as SSP. Release of N in available form was observed steadily from the day of incubation up to 270 DOI in all FPP treatments. In control available N ranged from 25 to 40 mg during the period of incubation.

Within the same FPP having similar P source having difference in single or double wrapping, it is found out that double layer packing was more efficient in the slow release of nutrients through them, rendering a slow and steady release. These results are in conformity to the findings of Surabi (2015), which indicated that the available N released till 12thweek of FPP (Single layer) placement (214 mg) coincided with the FPP having DAP as P source in Single + single combination (212 mg at 90 DOI) (T_1) of the present study, as both followed a steep increase and sustainedthe release towards the end.

Table 3. Release of available N from Fertilizer Pellet Pack in soil (mg)

T. No.	Days after Incubation																					
	0	**15**	**30**	**45**	**60**	**75**	**90**	**105**	**120**	**135**	**150**	**165**	**180**	**195**	**210**	**225**	**240**	**255**	**270**	**285**	**300**	**Mean**
T_1	29	77	289	349	599	665	955	1684	1715	1756	1915	1988	2034	2179	2311	2406	2462	2507	2579	2598	2622	1606
T_2	29	47	201	587	676	861	1005	1394	1493	1663	1703	1749	1816	2095	2189	2275	2359	2393	2415	2427	2466	1516
T_3	29	43	78	261	290	367	413	451	483	534	630	822	1033	1190	1396	1583	1622	1687	1701	1724	1731	860
T_4	29	42	60	176	181	203	284	368	411	475	613	801	899	1045	1165	1353	1578	1590	1612	1626	1639	769
T_5	29	63	121	91	145	210	296	551	601	842	1108	1205	1449	1671	1746	1851	1913	1964	1988	2012	2036	1042

T_6	29	51	100	73	88	189	257	324	448	570	878	959	1465	1524	1589	1671	1794	1852	1888	1909	1921	932
T_7	29	25	25	31	34	30	39	40	32	32	33	29	29	31	32	31	30	31	34	32	31	31
Mean	29	50	125	224	288	361	464	687	740	839	983	1079	1246	1391	1490	1596	1680	1718	1745	1761	1778	
			SED		CD				SED		CD				SED		CD					
	T		23.73		46.90		P		41.11		81.23		T x P		108.77		214.92					

Fertilizer N placed in each FPP = 3450 mg.

Release rate of Available N

With respect to available N, a sudden increase in the release (Fig. 3) was observed at 60 DOI to about 18 per cent in Single + single combination, more than 15 per cent in single + double in FPP having NPK with P as DAP which then fell down to 5 per cent at 120 DOI, and thereafter it gradually decreased to about 2 per cent. In the FPP having NPK with P as DAP + SSP an increase was observed at 120 DOI (15 %) and then showed a gradual decrease thereafter. In the FPP having NPK with P as SSP the increase occurred to a high level of about 12.5 per cent after 150 DOI and then gradually decreased.

Yoganathan (2016) [15] estimated the amount of N released to soil solution as leach out from FPP placed in moist soil. The release was much controlled in the early period up to 30 days, thereafter release increased at a faster rate. From FPP having butter paper wrap release of N washigh followed by single layer and double layer. In spite of encapsulation by poly coated pack with single or double layer almost similar release was noted as that of butter paper wrap. The reason attributed was that the first form of release of N from fertilizers would be gaseous ammonia which would have penetrated through the all barrier layers uniformly showing no limiting effect by the type of barrier layers.

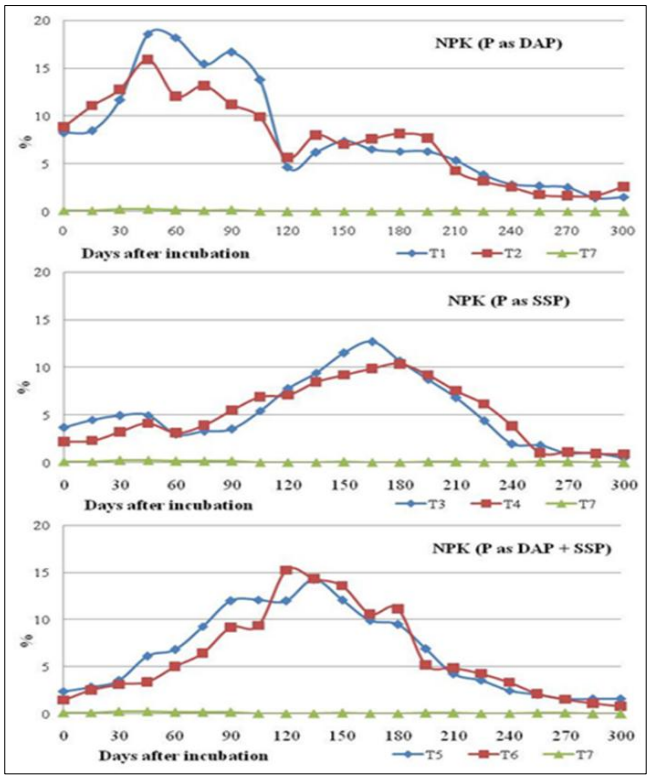


Fig 3: Release rate of available N in soil from fertilizer pellet pack (%)

Conclusion

From this laboratory study conducted, the amount of nutrient release was aimed to matchto the growth and maturity sugarcane. It was noted that FPP composition and layer combinations has to be in such a way that it should support by releasing the nutrients throughout the crops in various proportions matching to vital growing stages, meaning that the release should be slow, steady and sustain for long. Among the treatments, FPP with SSP as P source was found to satisfy the requirements.

References

1. Armour JD, Nelson PN, Daniells JW, Rasiah V,Inman-Bamber NG. Nitrogen leaching from the root zone of sugarcane and bananas in the humidtropics of Australia. Agriculture, Ecosystems and Environment. 2013; 180:68-78.
2. Connor S, Nelson PN, Armour JD, Henault C. Hydrology of a forested riparian zone in an agricultural landscape of the humid tropics. Agriculture, Ecosystems and Environment. 2013; 180:111-122.
3. Status paper on Sugarcaneby directorate of sugarcane development. Directorate of Sugarcane Development. Ministry of Agriculture, (Department of Agriculture &Cooperation) Aliganj, Lucknow (UP), 2013.
4. Huda A, Gaihre YK, Islam MR, Singh U, Islam R, Sanabria, JS, *et al*. Floodwater ammonium, nitrogen use efficiency and rice yields with fertilizer deep placement and alternate wettingand drying under triple rice cropping system. Nutrient Cycling in Agroecosystems. 2016; 104:53-66.
5. Libby R. Rensa, Lincoln Zotarellia, Diane L. Rowland, Kelly T. Morgan. Optimizing nitrogen fertilizer rates and time of application for potatoes under seepage irrigation. Field Crops Research. 2018; 215:49-58.
6. Mofijul Islam, Yam SM, Kanta Gaihre, Jatish Chandra Biswas, Md. Sarwar Jahan Md, Upendra Singh, *et al*. Different nitrogen rates and methods of application for dry season rice cultivation with alternate wetting and drying irrigation: Fate of nitrogen and grain yield. Agricultural Water Management. 2018; 196:144-153.
7. Muthukrishnan R, Arulmozhiselvan K, Padhmavadhi T. Assessment of electrolyte release characteristics from Nutripellet Pack technique. Trends in Biosciences. 2014; 7(19):2863-2869.
8. Nieder R, Benbi DK, Scherer HW. Fixation and defixation of ammoniumin soils: a review. Biology and Fertility of soils 2014; 47:1-14.
9. Rakkiyappan E, Thangavelu S, Bhagyalakshmi KV, Radhamani R. Uptake of Nitrogen, Phosphorus and Potassium by Some Promising Mid Late Maturing Sugarcane Clones. Sugarcane technology. 2007; 9(1):23-27.
10. Rasiah V, Armour JD, Cogle AL, Florentine SK. Nitrate import-export in interacting groundwater-surface water systems undercropping in a wet-tropical environment. Australian Journal of Soil Research. 2010; 48:361-370.
11. Rochette P, Angers DA, Chantigny MH, Gasser MO, Mc Donald JD, Pelster DE *et al*. Ammonia volatilization and nitrogen retention: How deep to incorporate urea? Journal of Environmental Quality. 2013; 42:1635-1642.
12. Surabhi Hota. Enhancing tomato yield and fertilizer use effieciency by Nutriseed Pack Technique under drip

irrigation. M.Sc. (Ag) thesis. Tamil Nadu Agricultural University, COIMBATORE, T.N. (INDIA), 2015.
13. Thorburn PJ, Biggs JS, Attard SJ, Kemei J. Environmental impacts of irri-gated sugarcane production: nitrogen lost through runoff and leaching. Agriculture Ecosystem and Environment 2011; 144:1–12.
14. Webster AJ, Bartley R, Armour JD, Brodie JE, Thorburn PJ. Reducing dissolved inorganic nitrogen in surface runoff water from sugarcane production systems. Marine Pollution Bulletin. 2012; 65:128-135.
15. Yoganathan G and Arulmozhiselvan K. Standardisation of soil conditions suitable for Nutripellet Pack for enhancing potato yield and nutrient use efficiency. 2016; 5(7):2804-2809.
16. Yoganathan G. Standardization of suitable methods for raising wetland rice and hill potato by nutripellet pack placement. M.Sc. (Ag) thesis. Tamil Nadu Agricultural University, Coimbatore, T.N. (India), 2016.