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Effect of Nutriseed Pack Technique on Yield and Nutrient Uptake of Maize Under Surface Irrigation

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Nutriseed pack technique is a way of deep placing fertilizer in the root zone simultaneously when sowing seed of crop. In order to evaluate the effect of different levels of nutrients viz., 75 per cent, 100 per cent and 125 per cent was provided through Nutriseed pack and in addition to nutrients furadan, neem cake also used to prepare Nutriseed pack. A field experiment was conducted with the test crop of hybrid maize COH(M)5 under surface irrigation. Nutriseed pack with furadan (with 100% NPK) recorded the highest N uptake of 65.4 and 55.1 kg ha^{-1} at harvest in stover and grain respectively. The Yield of COH(M)5 hybrid maize was higher with nutriseed pack placement. Nutriseed pack with furadan (with 100% NPK) recorded the highest grain yield of 5290 kg ha^{-1} which was 18.7 per cent higher than surface broadcast, and stover yield of 8500 kg ha^{-1} which was 17.7 per cent higher than surface broadcast.

Key words: Maize, Deep placement, Nutriseed pack technique, Nutrient uptake, Surface irrigation

Maize (*Zea mays* L.) is the third most important crop after rice and wheat with adaptability to diverse agro-climatic conditions around the World. Optimum nutrient management has long been acknowledged as being critical for producing high yield in Maize. However, there are multiple factors that cause decision making on fertilizer application to be a complex process. For instance, the rates of fertilizer application, the source of the nutrient and the associated availability to the crop, the time of application, and where the nutrient is placed are important considerations in nutrient management decisions. One means of increasing the nutrient supply without increasing the fertilizer amount is to improve the efficiency of fertilizer, which can be achieved through deep placement of the fertilizers. Natarajan and Manickam (1991) reported that more fertilizer N was utilized by rice with single deep placed urea super granule than with split applied prilled urea.

Fertilizer rates and placement of nutrients are important factors to be considered to produce maximum yield of maize. Particularly deep placement of nutrients might be beneficial to maize growth. Several studies have reported yield benefits to deep band nutrient placement in maize (Vyn and Janovicek, 2001). Increased early growth has been observed with deeper P placement (Borges and Mallarino, 2001) as well as by deep band placement of K when compared to broadcast application (Vyn *et al.,* 2002). The method of N, P and K placement has typically been found effective over broadcasting on the top of the soil, and it is also influenced by the amount of water used for irrigation (Howard *et al.,* 2002).

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Deivanai (2005) experimented with nutriseed holder in plastic which contained seed on top cavity, manure in the middle tube and fertilizer at bottom cavity, which gave 42-58 per cent increase in ADT 36 rice yield grown in soil column, when compared to surface broadcast method, under submerged water regime. Vengatesan (2007) modified plastic nutriseed holders into paper nutriseed packs and found that by deep placement by nutriseed packs maize yield could be increased to about 55 per cent under surface irrigation with 660 mm over the conventional surface fertilizer broadcast – surface irrigation method. In this study Nutriseed packs were made with manure and fertilizer pellets using a hand operated machine. The aspects of nutriseed pack technique have been brought out by Arulmozhiselvan *et al.* (2009).

The present study was planned and carried out in maize, by nutriseed pack technique which combines the promising aspects of deep placement of fertilizers, biocontrol agents, biofertilizers and compost under surface irrigation in comparison with conventional surface broadcast method of fertilizer application.

Materials and Methods

Design of nutriseed holder

The present nutriseed holder is a modification of previously designed nutriseed holders of Asha (2003) and Deivanai (2005). When it was first designed by Asha (2003), the entire unit was made out of glass. Deivanai (2005) modified the first design into three separate units as seed holder, manure tube and fertilizer holder using plastic material. These three units were fitted together as

single nutriseed pack. In the present study modification was attempted to replace butter paper and use newspaper so that it would be cheap and environmentally safe. Further, manure and fertilizers were pressed into pellets by a device, which was newly designed for this purpose.

Preparation of nutriseed pack.

The fertilizer materials needed to supply 100 or 75 per cent N and K as per treatment and 98 per cent of P, for a single maize plant was taken and placed in the pelleting device. Urea, single super phosphate and muriate of potash were used as nutrient sources. By pressing, about 30 mm length of fertilizer pellet was formed. Then the pellet was placed in a small thin polyethylene bag (1 X 1.5 inch) and the mouth was sealed with hot wire of sealing machine as a water proof pack.

For preparing manure pellet, enriched vermicompost was used. For this purpose 10 kg of vermicompost was mixed with 1 kg of single super phosphate and incubated for 30 days with adequate moisture. At the end of the period, the enriched manure was pellettized in the pelleting device. Every time 2-3 g of enriched compost was placed in the trough of pelleting device and then compressed into a pellet of 20-25 mm size. Each pellet contained about 2 per cent of the recommended P, for each plant.

When both fertilizer and manure pellets were made ready, they were assembled on a 6 x 6 cm perforated newspaper as a roll. The paper was placed on a flat surface. On middle lower portion of paper, first polythene packed fertilizer pellet was placed, coinciding to the bottom edge. Over fertilizer pellet, the manure pellet was placed. Then, one end of paper was flipped over the pellets and then folded as a roll. The closing edge of the paper roll was fixed with white adhesive and pasted. These rolls were then air dried and stored in cartons.

Few days before sowing in the inside top cavity of the paper roll one hybrid maize seed was put and pressed with slightly moist soil containing inoculants viz., Azophos (mixture of *Azospirillum* and Phosphobacteria) and *Trichoderma*. The extending paper length was folded inside to protect seed from falling. The roll which contained fertilizer pellet at bottom, manure pellet in the middle and seed with soil and bioinoculant, in total, is called as nutriseed pack.

Field experiment

A field experiment was conducted at Tamil Nadu Agricultural University, Coimbatore during 2008 - 09.

The field was ploughed well, leveled and ridges and furrows were formed at a distance of 60 cm. The soil of experimental field belongs to **Vertic Ustropept** of Periyanaickenpalayam series. The texture of the soil was sandy clay loam. The soil pH was 8.23 and the electrical conductivity was 0.89 dS m^{-1}. The organic carbon content of the soil was 0.53 per cent. The available soil nutrient status was low for available N (254 kg ha^{-1}), medium for available P (13.4 kg ha^{-1}) and high for available K (386 kg ha^{-1}). The field was divided in to plots of 5 X 4 m^2 in randomized block design. Seeds of maize hybrid CoH(M)5 were sown by dibbling directly for surface broadcast treatment and control; and by implanting nutriseed pack at one seed per sowing. The treatments details are as follow T_1 – Control;T_2 – 100% NPK - Surface application of Fertilizers; T_3 , T_4, T_5 : 75, 100, and 125% NPK- Nutriseed pack (Plain) ;T_6 –100% NPK- Nutriseed pack (Furadan); T7 -100% NPK- Nutriseed pack (Neem) ;T_8 –100% NPK- Nutriseed pack (Fertilizer + Manure mixture). Recommended cultural practices were followed throughout the growing period.The plant sample were analysed for the nutrients content as per the standard procedures

Results and Discussion

Dry matter production and Yield

The dry matter production recorded with nutriseed pack with Furadan (T_6) was 8298 kg ha^{-1} at milking stage and which was on par with T_5, T_7 and T_8 . The 100% NPK surface application of fertilizer (T_2) recorded lower value of dry matter weight (6606 kg ha^{-1}) than Nutriseed pack treatments. The control recorded the lowest dry matter production at all stages of crop growth.

The highest stover yield was observed with nutriseed pack with furadan (T_6) of 8500 kg ha^{-1} which was on par with T_4, T_7 and T_8.The nutriseed pack with furadan (T_6) recorded higher grain yield of 5290 kg ha^{-1} which was on par with T_5, T_7 and T_8 (Table1). This might be due to high status of available nutrients in deep placement throughout period of crop could be the evidence of the controlled release phenomenon. With higher nutrient availability and high nutrient uptake resulted under deep placement might have influenced dry matter production and yield.

Table 1. Dry matter production at different stages of crop and yield (kg ha^{-1}) under surface Irrigation

Treatment	Knee High	Tasseling	Milking	Harvest	
				Stover	Grain
T_1	2460	3805	4589	5071	3536
T_2	3276	5463	6606	7223	4458
T_3	3827	5261	6438	6987	4309
T_4	4722	6386	7279	7794	4836
I_5	5385	7108	7943	8243	5050
T_6	6180	7760	8298	8500	5290
T_7	6183	7581	8130	8388	5197
T_8	5799	7353	7898	8092	5061
SED	149	164	213	193	124
CD	321	351	456	414	265

T_1 – Control; T_2 –100% NPK - Surface application of fertilizers;T_3 , T_4, T_5 : 7_5, 100, and 125% NPK- Nutriseed pack (Plain) ;T_6 –100% NPK- Nutriseed pack (Furadan); T_7 - 100% NPK- Nutriseed pack (Neem) ; T_8 –100% NPK- Nutriseed pack (Fertilizer + Manure mixture)

In the previous attempts with deep placement, Bhuiyan (1988), Dhane *et al.* (1995) and Bautista *et al.* (2000) reported significant increase in yield due to fertilizer N, P and K placement in the root zone. Deivanai (2005) reported a yield increase of 63.3 per cent with plastic nutriseed pack placement over surface broadcast in soil column study growing direct seeded rice. The first work carried out on deep placement using Nutriseed pack resulted in the grain yield increase to the tune of 81.8 per cent over surface broadcast (Asha and Arulmozhiselvan, 2006).

Stover yield is a good indication of adequacy of nutrients in soil. Similar to the grain yield, stover yield also showed significant variation with deep placement. When compared to control nutriseed pack treatments produced 1916 to 3429 kg increase, whereas surface broadcast could record only 2152 kg increase. In terms of grain yield, when compared to control, nutriseed pack treatments registered 813 to 1754 kg increase, whereas surface broadcast could record only 922 kg increase.

In the nutriseed pack manure pellet P enriched vermicompost is included to give nutrient support particularly in the seedling growth stage. Addition of furadan and neem(Powder Form) were also included in manure pellets. Overall, in all nutriseed pack treatments the effect of vermicompost would also have been realized. By this addition the aim to create micro level integration of organic, inorganic and biological nutrient components in the root zone has been achieved. Orozco *et al.* (1996) stated that vermicompost contained most nutrients in plant-available forms such as nitrates, phosphates, and exchangeable calcium and soluble potassium. Findings of Arancon *et al.* (2006) indicated the beneficial effects vermicompost on growth of strawberries. There was marked decrease in total

Table 2. Nutrient uptake of maize (kg ha^{-1}) Under Surface Irrigation

Treatment	N uptake			P uptake			K uptake		
	Stover	Grain	Total	Stover	Grain	Total	Stover	Grain	Total
T_1	42.0	25.0	67.0	12.94	9.67	22.61	29.0	12.0	41.0
I_2	59.9	45.6	105.5	22.45	10.55	33.00	35.8	15.7	51.4
T_3	58.9	43.6	102.5	22.25	10.30	32.55	35.4	15.1	50.5
T_4	61.4	50.2	111.5	23.10	10.92	34.02	36.8	17.1	53.9
I_5	64.5	52.3	116.9	23.57	11.08	34.65	37.6	18.3	55.8
T_6	65.4	55.1	120.5	23.87	11.45	35.32	38.0	19.1	57.1
T_7	64.6	53.8	118.4	23.82	11.30	35.12	37.8	18.6	56.4
I_8	63.4	52.4	115.8	23.59	11.18	34.77	37.3	18.2	55.5
SED	2.19	1.20	2.66	0.99	0.50	1.18	0.98	0.63	1.13
CD	4.69	2.58	5.71	2.12	1.08	2.53	2.10	1.34	2.43

T_1-Control; T_2 -100% NPK - Surface application of fertilizers;T_3 ' T_4 T_5 : 75, 100, and 125% NPK- Nutriseed pack (Plain) ;T_6 -100% NPK- Nutriseed pack (Furadan); T7 .100% NPK- Nutriseed pack (Neem) ; T_8 -100% NPK- Nutriseed pack (Fertilizer + Manure mixture)

N in soils without vermicompost application in comparison with vermicompost treated soils due to larger amounts of total C and N in vermicompost that could have provided a larger source of N for mineralization.

Nitrogen uptake

The nutriseed pack with furadan (T_6) recorded the highest uptake of 65.4 and 55.1 kg ha^{-1} in stover and grain respectively at harvest. Greater N uptake was realized under nutriseed pack technique. Application of entire dose of urea in a single stroke along with single super phosphate and muriate of potash in the nutriseed pack resulted in the high N availability, which might be the reason for enhanced N uptake. Mengel *et al.* (1988) stated that surface applied urea had poor N use efficiency particularly due to volatilization and immobilization leading to reduced N uptake.

Compared with unfertilized control, nutriseed pack with furadan has nearly doubled the N uptake which indicated the importance of fertilization with N, particularly in soils with low available N status. Similar responses to added N were reported by Hussain (1976), Rafiq and afzal (1982), and Khattak *et al.* (1988).

Phosphorus Uptake

The stover and grain P uptake ranged between 12.94 to 23.87 and 9.67 to 11.45 kg ha^{-1} respectively. Nutriseed pack with Furadan (T_6) recorded a uptake value of 23.87 kg ha^{-1} in stover and 11.45 kg ha^{-1} in grain respectively. Among the fertilizer placement methods, P uptake was very high under nutriseed pack treatments. Under nutriseed pack with furadan there was 12.71 kg increase in P uptake over the unfertilized control, showing the definite response for the applied P that was higher for deep placement. Deeply placing fertilizers as a spot application in nutriseed pack has several advantages, particularly with relatively immobile nutrients like P and K in soil. It would reduce quick dissolution and mobility of soluble P due to slow diffusion from the applied location as found in the laboratory studies conducted in the present investigation to assess the pattern of nutrient release. This would be the reason for enhanced P uptake as the P remained in soluble form for longer duration. Similar findings were reported by Borges and Mallarino (2001).

Potassium Uptake

Even though nutriseed pack treatments enhanced significant K uptake over surface broadcast, the different K levels and additives imposed did not result in significantly different K uptake among nutriseed pack treatments. Higher status of available K of the experimental soil might have masked the effect of surface application of K fertilizer.

The stover and grain uptake associated with Nutriseed pack with Furadan (T_6) was 38.0 and 19.1 kg /ha respectively. Localized placement of K as done with nutriseed pack placement might have limited the chance to get into non-exchangeable K pool, hence would have exhibited prolonged release of water soluble K within the root zone and enhanced the K uptake by maize. The result of nutrient release study conducted separately in the present investigation stands in testimony to the enhanced K uptake found with nutriseed pack. Further, the recorded results also corroborate to the findings of Iqbal *et al*. (2007) who found that the application of K at sowing time increased enzyme activation which increased flag leaf and average leaf area thus resulted in the highest grain yield of maize.

Conclusion

The Yield of COH(M)5 hybrid maize was high with nutriseed pack placement. Nutriseed pack with furadan (with 100% NPK) recorded the highest grain yield of 5290 kg ha^{-1} which was 18.7 per cent higher than surface broadcast, and stover yield of 8500 kg ha-1 which were 17.7 per cent higher than surface broadcast. Further, stover and grain yield recorded under nutriseed pack with Furadan was comparable with nutriseed pack with 125% NPK. Nutriseed pack with furadan has recorded the highest N uptake of 30.0, 50.0, 60.5 kg ha^{-1} at knee high, tasseling and milking stages and uptake of 65.4 and 55.1 kg ha^{-1} at harvest in stover and grain, respectively.

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