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Effect of Urease and Nitrification Inhibitors on Productivity and Profitability of Aerobic Rice During Summer Season

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Abstract

A two years field experiment was conducted at the Agronomy field unit, Zonal Agricultural Research Station, UAS-B, GKVK, Bengaluru during summer, 2022 and 2023 to assess the efficacy of urease and nitrification inhibitors on productivity and profitability of aerobic rice. The experiment was laid out in Randomized Complete Block Design with nine treatments (Urea, Urea + HQ @ 4000 mg kg^{-1} urea, Urea + HQ @ 8000 mg kg^{-1} urea, Urea + HQ @ 12000 mg kg^{-1} urea, Urea + DCD @ 4000 mg kg^{-1} urea, Urea + DCD @ 8000 mg kg^{-1} urea, Urea + DCD @ 12000 mg kg^{-1} urea, Neem coated urea and Absolute control), each replicated thrice. Significantly higher plant height (72.27 cm), number of tillers $plant^{-1}$ (22.83), dry matter production (53.70 g $plant^{-1}$), number of green leaves $plant^{-1}$ (85.03) and leaf area (2108 cm^2 $plant^{-1}$) at 90 DAS and panicle length (22.14 cm), grain weight (2.93 g), grain yield (4717 kg ha^{-1}), straw yield (5796 kg ha^{-1}) and gross returns (Rs.106845 ha^{-1}) were recorded with application of Urea + HQ @ 12000 mg kg^{-1} urea compared to other treatments on pooled basis. However, application of neem coated urea found to be more economical with significantly higher net returns (Rs.55662 ha^{-1}) and B:C (2.28) compared to other treatments.

Keywords : Aerobic rice, Dicyanamide, Hydroquinone, Yield and economics

Rice (*Oryza sativa* L.) is one of the world's most vital staple crops, serving as a primary source of sustenance for over half of the global population. Traditionally, rice cultivation involves transplanting the young seedlings into puddled soil under flooded conditions followed by continuous water stagnation on field throughout the cropping period under low land conditions. This causes destruction of soil structure ultimately causing land degradation in the long run (Naveen Kumar *et al*., 2021 and Kalita *et al*., 2022). There are signs that declining water availability is threatening the sustainability of this system as it requires 3,000 to 5,000 L of water to produce one kg of grain (Anusha, 2015). Among the various innovative technologies developed across the world towards enhanced resource use efficiency, the concept of 'aerobic rice' developed from China (Bouman and Tuong, 2001) has disproved the theory that rice thrives well only in water and has shown that it can also flourish in dry soils without the need for continuous flooding. Hence, aerobic rice cultivation has emerged as a water-saving technology (uses around 50 per cent of the water required in puddled transplanted rice system), offering a solution to current water scarcity challenges faced by farmers (Gandhi *et al*., 2012).

Though, aerobic rice cultivation is a good alternative to traditional flooded rice systems in water usage perspective, the yield levels are still pressed by various constraints. Among them, nitrogen management is of crucial importance as rice is a nitro-positive crop that demands nitrogen in larger quantities compared to most of the other cereals (Theerthana *et al*., 2022). In aerobic systems, efficient nitrogen management is of paramount importance due to the absence of continuous flooding. The challenges include increased nitrogen losses through volatilization, leaching and denitrification, as well as higher vulnerability to nutrient runoff (Pelster *et al*., 2018, Sigurdarson *et al*., 2018 and Jayanthi *et al*., 2022). Additionally, aerobic rice often experiences greater competition from weeds, necessitating strategic nitrogen allocation to both the crop and weed management. To satisfy crop nitrogen demands owing to these losses, farmers are indiscriminately applying excess nitrogen fertilizers, which is economically costly and ecologically detrimental. Precise timing and application methods are necessary to prevent nitrogen wastage and environmental impacts.

The urgency of this research is underscored by the fact that rice production must double by 2050 to meet the nutritional demands of the projected global population (Anonymous, 2023). Achieving this ambitious goal in a sustainable and environ -mentally responsible manner necessitates innovative approaches to nitrogen management in rice cultivation. Supplying the nutrients in quantities to match the crop demand is a tedious job. On the other hand, slowing down the process of nutrient mineralization within the soil it self can be a viable and economical option. At present, it is possible to slow down the nitrogen mineralization through use inhibitors *viz.* urease and nitrification inhibitors in the soil. Urease inhibitors primarily target the enzyme urease, which is responsible for the hydrolysis of urea-based nitrogen fertilizers into ammonium. By suppressing urease activity, these inhibitors slow down the conversion of urea to ammonium, thereby extending the duration of nitrogen availability to plants (Lan *et al.*, 2022). On the other hand, nitrification inhibitors impede the oxidation of ammonium to nitrate, thus reducing the potential for nitrate leaching and nitrous oxide emissions (Lasisi *et al.,* 2020). When integrated into aerobic rice systems, these inhibitors have the potential to revolutionize nitrogen management strategies, offering a host of benefits ranging from enhanced NUE to minimized environmental harm. As we embark on this exploration, we look forward to unveiling the transformative possibilities that urease and nitrification inhibitors hold for the future of rice production and global food security.

MATERIAL AND METHODS

The field experiment was conducted at the Agronomy field unit, Zonal Agricultural Research Station, UAS-B, GKVK, Bengaluru during summer, 2022 and 2023. This site comes under Eastern Dry Zone (Agro-Climatic Zone V) of Karnataka at a latitude of 12º 58' North, longitude of 77º 33' East and an altitude of 930 m above mean sea level. The actual rainfall received throughout the cropping period at the experimental site 717.8 and 271.4 mm during 2022 and 2023, respectively. The soil was red sandy loam in texture that comes under Alfisolsoil order. Soil was acidic in reaction (pH 5.9), low in organic carbon content (4.5 mg kg^{-1}) with an electrical conductivity of 0.21 dS m^{-1}. The soil was initially medium in fertility status with respect to available nitrogen (248.61 kg ha^{-1}), phosphorous (28.85 kg ha^{-1}) and potassium (176.89 kg ha^{-1}). Aerobic rice was sown @ 5 kg ha^{-1} seed rate using KMP 175 variety at a spacing of 25 cm × 25 cm. The experiment was laid out in Randomized Complete Block Design with nine treatments and three replications. The nine nitrogen management treatments were, T_1 : Urea, T_2 : Urea + HQ @ 4000 mg kg^{-1} urea, T_3: Urea + HQ @ 8000 mg kg^{-1} urea, T_4 : Urea + HQ @ 12000 mg kg^{-1} urea, T_5 : Urea + DCD @ 4000 mg kg^{-1} urea, T_6 : Urea + DCD @ 8000 mg kg^{-1} urea, T_7 : Urea + DCD @ 12000 mg kg^{-1} urea, T_8 : Neem coated urea and T_9 : Absolute control [Note : HQ-Hydroquinone (Urease inhibitor), DCD - Dicyanamide (Nitrification inhibitor)]. For T_1-T_7 treatments, lab grade urea was used and in T_8 treatment neem coated urea is used at 100 kg N ha^{-1}. FYM @ 10 t ha^{-1}, phosphorous and potassium @ 50 kg each ha^{-1} was commonly applied to all the treatments except absolute control treatment (as per UASB - PoP). Rest of the agronomic practices were followed as per the recommendation for all the treatments in common. Hydroquinone (urease inhibitor) and Dicyanamide (nitrification inhibitor) were procured from Sigma Aldrich Chemicals Pvt. Ltd. As per the treatments, the quantity of chemicals was weighed and made into water solution prior to use. Immediately after application of urea fertilizer (at sowing, 30 and 60 DAS), the solution containing inhibitors was applied to soil through foliar application as per treatments.

Five plants from each plot were randomly selected from the net plot and tagged. These plants were used for recording growth and yield attributes observations. The plant height was measured from the ground level to base of the flag leaf. The number of tillers and green leaves per plant were recorded from the tagged plants. The plants from the gross plot were cut above the ground and leaves were fed to leaf area meter for estimating the photosynthetically active area (leaf area). The same plants were oven dried at 65-70 ^{0}C and the dry weight per plant was noted. The plants from the net plot were harvested and threshed separately and the grain and straw yield were recorded and expressed on hectare basis. The average of all the replications was is expressed as mean values of the respective treatments.

The data recorded on various parameters were subjected to Fisher's method of analysis of variance and interpretation of the data was made as given by Gomez and Gomez (1984). The level of significance used in 'F' and 't' test was P = 0.05. Whenever F-test was significant for comparison amongst the treatments means the critical differences (CD) was worked out. otherwise against CD values abbreviation 'NS' (Non-significant) is indicated.

Results and Discussion

Growth Attributes

The data pertaining to growth attributes of aerobic rice as influenced by urease and nitrification inhibitors is presented in Table 1 & 2 as depicted in Plate 1. The

Table 1

Effect of urease and nitrification inhibitors on plant height, no. of tillers plant^{-1} and dry matter production of aerobic rice at 90 DAS

Treatment	Plant height (cm)			No. of tillers plant^{-1}			Dry matter production (g plant^{-1})		
	2022	2022	2022	2022	2023	Pooled	51.31	45.29	48.30
Urea	66.73	63.27	65.00	22.10	18.97	20.53	54.80	48.29	51.55
Urea + HQ @ 4000 mg kg^{-1} urea	71.27	67.47	69.37	23.60	20.23	21.92	56.17	49.49	52.83
Urea + HQ @ 8000 mg kg^{-1} urea	73.04	69.14	71.09	24.19	20.73	22.46	57.10	50.31	53.70
Urea + HQ @ 12000 mg kg^{-1} urea	74.25	70.28	72.27	24.59	21.08	22.83	53.35	47.01	50.18
Urea + DCD @ 4000 mg kg^{-1} urea	69.37	65.67	67.52	22.97	19.69	21.33	54.10	47.67	50.88
Urea + DCD @ 8000 mg kg^{-1} urea	70.35	66.60	68.47	23.30	19.97	21.63	55.32	48.74	52.03
Urea + DCD @ 12000 mg kg^{-1} urea	71.94	68.09	70.01	23.82	20.42	22.12	53.03	46.73	49.88

Continued....

Table 1 Continued....

Treatment	Plant height (cm)			No. of tillers plant^{-1}			Dry matter production (g plant^{-1})		
	2022	2022	2022	2022	2023	Pooled	51.31	45.29	48.30
Neem coated urea	68.96	65.28	67.12	22.84	19.58	21.21	27.97	24.89	26.43
Absolute control	36.37	34.77	35.57	12.04	10.43	11.24	0.56	0.50	0.36
S.Em.±	0.73	0.69	0.49	0.24	0.21	0.16	1.68	1.49	1.05
CD (0.05)	2.19	2.08	1.41	0.73	0.62	0.45	51.31	45.29	48.30

TABLE 2

Effect of urease and nitrification inhibitors on number of green leaves plant^{-1}, leaf area and leaf area index at 90 DAS of aerobic rice

Treatment	No. of green leaves plant^{-1}			Leaf area (cm^2 plant^{-1})			Leaf area index		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
Urea	78.74	74.20	76.47	1953	1838	1896	3.13	2.94	3.03
Urea + HQ @ 4000 mg kg^{-1} urea	84.10	79.12	81.61	2086	1960	2023	3.34	3.14	3.24
Urea + HQ @ 8000 mg kg^{-1} urea	86.20	81.09	83.64	2138	2009	2074	3.42	3.21	3.32
Urea + HQ @ 12000 mg kg^{-1} urea	87.63	82.43	85.03	2174	2042	2108	3.48	3.27	3.37
Urea + DCD @ 4000 mg kg^{-1} urea	81.86	77.02	79.44	2031	1908	1970	3.25	3.05	3.15
Urea + DCD @ 8000 mg kg^{-1} urea	83.02	78.10	80.56	2059	1935	1997	3.29	3.10	3.20
Urea + DCD @ 12000 mg kg^{-1} urea	84.89	79.86	82.37	2106	1979	2042	3.37	3.17	3.27
Neem coated urea	81.37	76.56	78.97	2019	1897	1958	3.23	3.04	3.13
Absolute control	42.92	40.78	41.85	1065	1010	1038	1.70	1.62	1.66
S.Em.±	0.87	0.81	0.58	21.49	20.14	14.29	0.03	0.03	0.02
CD (0.05)	2.58	2.44	1.66	64.12	60.38	41.06	0.10	0.10	0.07

Urea Urea + HQ @ 1200 mg kg urea Absolute control

Plate 1 : Comparison of aerobic rice performance under application of urea, urea + HQ @ 12000 mg kg-1 urea and absolute control treatments at harvest stage

treatment receiving urea + HQ @ 12000 mg kg^{-1} urea resulted in significantly higher plant height (74.25 and 70.28 cm), number of tillers $plant^{-1}$ (24.59 and 21.08) and dry matter production (57.10 and 50.31 g $plant^{-1}$) at 90 DAS during summer, 2022 and 2023, respectively. This was how ever found to be at par with application of urea + HQ @ 8000 mg kg^{-1} urea (73.04 & 69.14 cm, 24.19 & 20.73 and 56.17 & 49.49 g $plant^{-1}$, respectively). These enhanced growth attributes are a result of efficient production and supply of photosynthates. The significantly higher number of green leaves, leaf area and leaf area index were also observed under application of urea + HQ @ 12000 mg kg^{-1} urea (85.03, 2108 cm^2 $plant^{-1}$ and 3.37, respectively on pooled basis). This treatment was at par with application of urea + HQ @ 12000 mg kg^{-1} urea (83.64, 2074 cm^2 $plant^{-1}$ and 3.32, respectively on pooled basis) (Table 2). These results are in conformity with the findings of Freney *et al*. (1995), Jayadeva (2007) and Kumar *et al*. (2007). This is attributed to supply of nitrogen to the plants slowly and steadily for longer period of time due to application of inhibitors along with the urea. The connection between the increased leaf number and area with greater plant height, the number of tillers and dry matter production under higher nitrogen supply is rooted in the intricate physiological dynamics of nitrogen's impact on plant growth. Nitrogen is an essential component in chlorophyll, crucial for photosynthesis. Elevated nitrogen availability promotes chlorophyll production, leading to more efficient photosynthesis (Lemraski *et al.,* 2017 and Lalitha, 2020). This increased photosynthetic activity results in the development of a greater number of leaves and increased leaf area, facilitating enhanced light capture and CO_2 assimilation. As a result, plants grow taller and produce more tillers to harness additional resources, ultimately leading to greater dry matter production due to improved metabolic processes and resource utilization driven by ample nitrogen supply (Zhang *et al*., 2017). Availability of this essential nutrient at minute quantities under absolute control treatment resulted in significantly lower growth attributes.

In general, there was better growth of plant in terms of growth attributes with the application of urease or nitrification inhibitors as compared to application of only urea due to continuous supply of nitrogen to plants. Urease inhibitors reduce the conversion of urea into ammonia, preventing nitrogen loss through volatilization. Nitrification inhibitors slow down the conversion of ammonium to nitrate, retaining ammonium nitrogen in the soil. These mechanisms collectively extend the availability of nitrogen to plants over a more extended period, ensuring a consistent and efficient nutrient supply for sustained plant growth (Abalos *et al*., 2014 and Rose *et al*., 2018).

Yield Attributes and Yield

The data pertaining to yield attributes of aerobic rice as influenced by urease and nitrification inhibitors is presented in Table 3 and 4. Application of urea + HQ @ 12000 mg kg^{-1} urea recorded significantly higher

TABLE 3

Effect of urease and nitrification inhibitors on yield attributes of aerobic rice

Treatment	Panicle length (cm)			Grain weight $panicle^{-1}$ (g)			Test weight (g)		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
Urea	20.41	19.28	19.84	2.72	2.54	2.63	16.35	16.33	16.34
Urea + HQ @ 4000 mg kg^{-1} urea	21.84	20.60	21.22	2.91	2.71	2.81	16.97	16.54	16.75
Urea + HQ @ 8000 mg kg^{-1} urea	22.40	21.13	21.77	2.99	2.78	2.88	17.41	16.96	17.18

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Table 3 Continued....

Treatment	Panicle length (cm)			Grain weight panicle^{-1} (g)			Test weight (g)		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
Urea + HQ @ 12000 mg kg^{-1} urea	22.79	21.49	22.14	3.04	2.83	2.93	17.70	17.25	17.48
Urea + DCD @ 4000 mg kg^{-1} urea	21.24	20.04	20.64	2.83	2.64	2.73	16.50	16.08	16.29
Urea + DCD @ 8000 mg kg^{-1} urea	21.55	20.33	20.94	2.88	2.67	2.77	16.74	16.32	16.53
Urea + DCD @ 12000 mg kg^{-1} urea	22.05	20.80	21.43	2.94	2.74	2.84	17.13	16.70	16.91
Neem coated urea	21.11	19.91	20.51	2.82	2.62	2.72	16.48	16.44	16.46
Absolute control	15.39	14.87	15.13	2.12	2.02	2.07	16.17	16.13	16.15
S.Em.±	0.23	0.22	0.15	0.03	0.03	0.02	0.18	0.18	0.12
CD (0.05)	0.69	0.66	0.44	0.09	0.09	0.06	NS	NS	NS

TABLE 4

Effect of urease and nitrification inhibitors on grain yield, straw yield and harvest index of aerobic rice

Treatment	Grain yield (kg ha^{-1})			Straw yield (kg ha^{-1})			Harvest index		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
Urea	4366	4234	4300	5463	5303	5383	0.4442	0.4439	0.4441
Urea + HQ @ 4000 mg kg^{-1} urea	4673	4525	4599	5834	5655	5745	0.4447	0.4445	0.4446
Urea + HQ @ 8000 mg kg^{-1} urea	4793	4641	4717	5979	5796	5887	0.4449	0.4447	0.4448
Urea + HQ @ 12000 mg kg^{-1} urea	4875	4720	4797	6078	5892	5985	0.4451	0.4448	0.4449
Urea + DCD @ 4000 mg kg^{-1} urea	4545	4401	4473	5679	5505	5592	0.4445	0.4443	0.4444
Urea + DCD @ 8000 mg kg^{-1} urea	4611	4465	4538	5759	5582	5671	0.4446	0.4444	0.4445
Urea + DCD @ 12000 mg kg^{-1} urea	4718	4569	4643	5889	5708	5798	0.4448	0.4446	0.4447
Neem coated urea	4516	4374	4445	5645	5472	5559	0.4445	0.4442	0.4443
Absolute control	2009	1949	1979	2611	2538	2575	0.4348	0.4343	0.4346
S.Em.±	50	48	33	60	58	41	0.0002	0.0002	0.0001
CD (0.05)	148	144	96	179	174	116	0.0005	0.0006	0.0004

panicle length (22.79 & 21.49 cm) and grain weight panicle^{-1} (3.04 & 2.83 g) during summer, 2022 and 2023, respectively which was found to be at par with application of urea + HQ @ 8000 mg kg^{-1} urea (22.40 & 21.13 cm and 2.99 & 2.78 g, respectively). Though, test weight did not vary significantly among the treatments imposed, numerically higher test weight was observed under application of urea + HQ @ 12000 mg kg^{-1} urea (17.48 g) compared to other treatments on pooled basis. The increase in yield attributes is closely linked to the enhancement of growth attributes due to higher nitrogen availability. Nitrogen stimulates better plant growth attributes which collectively contribute to greater photosynthetic capacity and resource utilization resulting in more robust panicle development, increased grain weight and higher test weight. Essentially, nitrogen availability fosters improved plant growth which in turn boosts grain production. These results are in line with the findings of Modol *et al*. (2018) and Lasisi *et al*. (2020).

Significantly higher grain yield, straw yield and harvest index were also observed under the application of urea + HQ @ 12000 mg kg^{-1} urea (4797 kg ha^{-1}, 5985 kg ha^{-1} and 0.4449, respectively) which was at par with application of urea + HQ @ 8000 mg kg^{-1} urea (4717 kg ha^{-1}, 5887 kg ha^{-1} and 0.4448, respectively) on pooled basis as shown in Table 4. The better growth and yield attributes together resulted in significantly higher yield levels. Mohammed *et al.* (2016) and Liu *et al.* (2019) also reported similar results in other cereals.

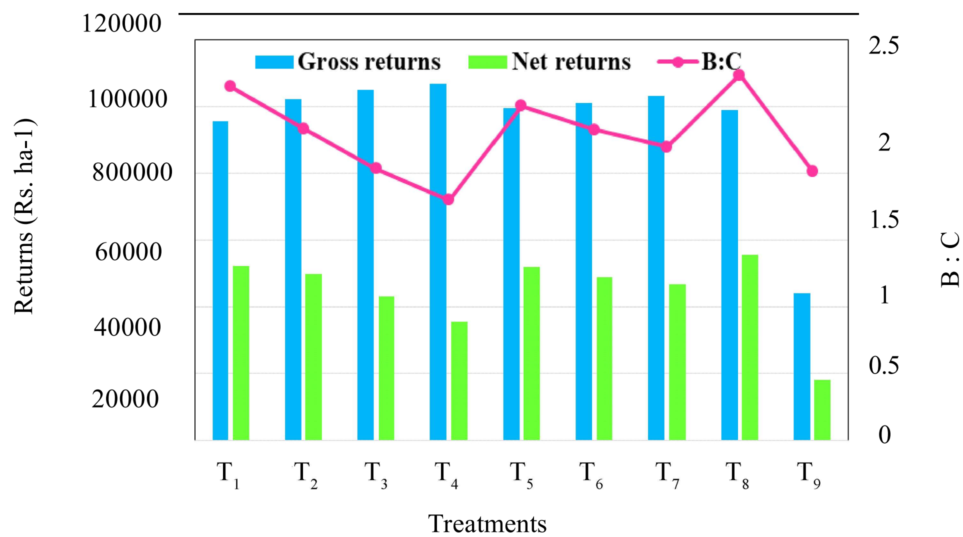
Nitrogen Uptake by Crop

Nitrogen uptake by grain, straw and total plant were significantly higher in treatments receiving urease and nitrification inhibitors over application of only urea. The total nitrogen uptake by rice was 3.86 to 13.61 per cent higher under application of urea + 12000 mg kg^{-1} urea than other nitrogen fertilized treatments (Table 5). However, this was found to be at par with application of urea + 8000 mg kg^{-1} urea. The increased nitrogen uptake by crop when urease and nitrification inhibitors were used along with urea is mainly attributed to slow and steady release of nitrogen in the soil by inhibition of the enzymes involved in urea hydrolysis. Thus, availability of nitrogen for longer time in soil resulted in efficient up take by crop which led to reduced loss of highly mobile nitrogen from

TABLE 5

Effect of urease and nitrification inhibitors on nitrogen uptake (kg ha-1) by aerobic rice at harvest

Treatment	Grain			Straw			Total		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
Only urea	50.25	47.01	48.63	45.25	43.07	44.16	95.50	90.08	92.79
Urea + HQ @ 4000 mg kg^{-1} urea	54.48	50.99	52.74	48.87	46.41	47.64	103.35	97.40	100.38
Urea + HQ @ 8000 mg kg^{-1} urea	56.14	52.58	54.36	50.29	47.74	49.01	106.43	100.32	103.37
Urea + HQ @ 12000 mg kg^{-1} urea	57.27	53.67	55.47	51.25	48.65	49.95	108.52	102.31	105.42
Urea + DCD @ 4000 mg kg^{-1} urea	52.72	49.29	51.00	47.36	44.98	46.17	100.07	94.28	97.18
Urea + DCD @ 8000 mg kg^{-1} urea	53.63	50.17	51.90	48.14	45.72	46.93	101.76	95.88	98.82
Urea + DCD @ 12000 mg kg^{-1} urea	55.11	51.59	53.35	49.40	46.91	48.15	104.51	98.50	101.50
Neem coated urea	52.33	48.92	50.63	47.03	44.67	45.85	99.35	93.59	96.47
Absolute control	17.73	15.70	16.71	17.46	16.86	17.16	35.19	32.55	33.87
S.Em.±	0.68	0.66	0.46	0.59	0.55	0.39	1.27	1.21	0.85
CD (0.05)	2.04	1.97	1.32	1.75	1.65	1.12	3.79	3.62	2.44



Legend

T_1:Urea, T_2: Urea + HQ @ 4000 mg kg^{-1} urea, T_3: Urea + HQ @ 8000 mg kg^{-1} urea, T_4: Urea + HQ @ 12000 mg kg^{-1} urea, T_5: Urea + DCD @ 4000 mg kg^{-1} urea, T_6: Urea + DCD @ 8000 mg kg^{-1} urea, T_7: Urea + DCD @ 12000 mg kg^{-1} urea, T_8: Neem coated urea, T_9: Absolute control

Fig. 1 : Effect of Urease and Nitrification Inhibitors on Economics of Aerobic Rice

soil through volatilization or leaching. While, application of only urea is subjected to rapid hydrolysis leading to more loss of nitrogen from soil due to non-synchrony between crop requirement and soil available nitrogen. Even application of neem coated urea resulted in significantly higher total nitrogen uptake (96.47 kg ha^{-1}) than only urea application (92.79 kg ha^{-1}) due its slow releasing action that in turn reduced the losses. These results are in agreement with the findings of Jayadeva (2007), Thind *et al.* (2010), Meng *et al*. (2020) and Lan *et al*. (2022).

Economics

The data pertaining to economics of aerobic rice as influenced by urease and nitrification inhibitors is presented in Fig. 1. Significantly higher gross returns was recorded with application of urea + HQ @ 12000 mg kg^{-1} urea (Rs.106845 ha^{-1}) which was at par with application of urea + HQ @ 8000 mg kg^{-1} urea (Rs.105057 ha^{-1}). While significantly lower gross returns was noted with absolute control (Rs.44236 ha^{-1}) on pooled basis. This is attributed to the significant difference among the treatments with respect to yield levels, which is when converted on monetary basis resulted in similar variation among the treatments with respect to gross returns. Higher economic returns with application of slow-release fertilizers were also noted by Jayadeva (2007), Suresh Naik (2014) and Ravi (2015).

In contrast to gross returns, net returns and B:C were significantly higher under application of neem coated urea (Rs.55662 ha^{-1} and 2.28) compared to other treatments. This higher net returns and B:C ratio inspite of lesser yield compared to use of urease and nitrification inhibitors is mainly attributed to the higher cost incurred on their purchase and application.

Though, use of urease and nitrification along with urea resulted in significantly higher productivity of aerobic rice, they also proved to be uneconomical because of their higher market prices. Hence, neem coated urea is recommended for the farmers (which already farmers are using in fields) over urea (lab grade) for higher and sustainable rice yield levels. However, the present study encompasses the wide scope in using urease and nitrification inhibitors by the farmers, if developed by the manufacturers and accessible to farmers at lower costs.

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