Global Scientific JOURNALS

GSJ: Volume 11, Issue 11, November 2023, Online: ISSN 2320-9186
www.globalscientificjournal.com

Evaluation of judicious use of nitrogen by using green seeker technology with comparison to other technologies in rice crop

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KeyWords
Green Seeker; lower input cost; improve N efficiency; Economic returns; Leaf Color Chart

ABSTRACT

Prices of inorganic fertilizers are increasing day by day and farmers depend on application of these fertilizers which increases cost of production of rice crop. Farmers applied un-judicious and over dose of nitrogenous fertilizers in rice crop. This multi-year and multi-location study was conducted for nitrogen (N) management using Green Seeker (GS), leaf color chart (LCC) and departmental recommendation (DR) which were compared to farmers' practice (FP) in order to reduce N and yield losses of rice, during 2017-2019. The number of tillers and yield recorded at Pindi Bhattian and Challianwala were differed non-significantly during 2017. However, significant difference in yield was recorded in GS (2860 kgha^{-1}) and LCC (2760 kgha^{-1}) compared to DR (2480 kgha^{-1}) and FP (2230 kgha^{-1}) at Phalia. The number of tillers and yield was non-significantly differed at Mangat Neecha (District M. B. Din) during 2018. In case of LCC number of tillers recorded significantly higher compared to other treatments at Raikay (M. B. Din) but yield was non-significant. Similar trend for tillers and yield was recorded at Bilal Pur. Green Seeker and Leaf Color Chart showed similar trend in yield (3843 & 3753 kgha^{-1}) but differed significantly with Departmental Recommendations (3487 kgha^{-1}) and FP (3353 kgha^{-1}) at Kotli Mano Sidhuwan (District Gujranwala). At Nandipur (District Gujranwala), significantly higher tillers were recorded in GS, LCC and DR treatments compared to FP; however yield in GS (4070 kgha^{-1}) and LCC (4153 kgha^{-1}) was significantly higher compared to DR (3623 kgha^{-1}) and FP (3097 kgha^{-1}). The number of tillers differed non-significantly at Raikay but yield of DR (4877 kgha^{-1}), LCC (4413 kgha^{-1}) and GS (4437 kgha^{-1}) was significantly higher as compared to FP (3717 kgha^{-1}). The net returns (Rs. 109529 ha^{-1}) and BCR (2.02) were recorded high in Green Seeker followed by LCC. These techniques improve nitrogen fertilizer efficiency resulted to reduce the input cost in transplanted rice crop. In conclusion, Green Seeker is an easy to use, cost effective technique for effectively improving nitrogen fertilizer management in transplanted rice followed by leaf color chart (LCC) and other treatments without compromising the yield while saving nitrogen fertilizer and improving economic benefits of the farmers.

Introduction

Rice (*Oryza sativa* L.) is considered major food crop and consumed by one third of planet. The analysis of chemical composition showed that it has seven hundred calories (Tari et al., 2009). In rice crop, the farmer's use un-judicious and high amounts of nitrogenous fertilizers. The prices of inorganic fertilizers increases day by day and farmers depend on application of these fertilizers, which increases cost of production of rice crop. The cost of production of nitrogen is high in the market due to higher dollar prices and inflation. Due to inflation the farming community is facing shortfall of nitrogenous fertilizers. Judicious use of N based on plant need improves fertilizer efficiency. Early development phases are characterized by soil nitrogen (N) accumulation that leads to canopy closure, but later growth stages are characterized by the majority of the N in new leaves coming from the lower leaves as a result of canopy senescence.

Plant N status has been determined using a number of non-destructive diagnostic methods, including SPAD and Green Seeker and Leaf Color Chart (Peng et al., 1996; Zhu et al., 2008; Iqbal et al., 2016). The performance of the Green Seeker sensor for irrigated rice may be impacted by the presence of water in the field. In paddy fields, it was discovered that spectral reflectance decreased with increasing water depth, and that water had a greater impact on rice during its early stages of growth (Kanke et al., 2016; Shikada and Miyakita, 1992). Leaf color card (LCC) is a user-friendly and cost-effective diagnostic tool that monitors the relative greenness of rice leaves as an indicator of plant N status. Low-cost leaf color cards (LCCs) have proven to be a quick and reliable tool for determining when to apply fertilizer to crops (Yoseftabar, 2013; Iqbal et al., 2016).

Hence, this scientific study was conducted with objective to reduce the N and rice yield losses using different nitrogen management techniques including Green Seeker/ normalized difference vegetation index (NDVI) readings, leaf color chart and departmental recommendations in comparison to the farmers' practice in rice-wheat cropping system of Gujranwala Zone, Punjab-Pakistan.

Materials and Methods

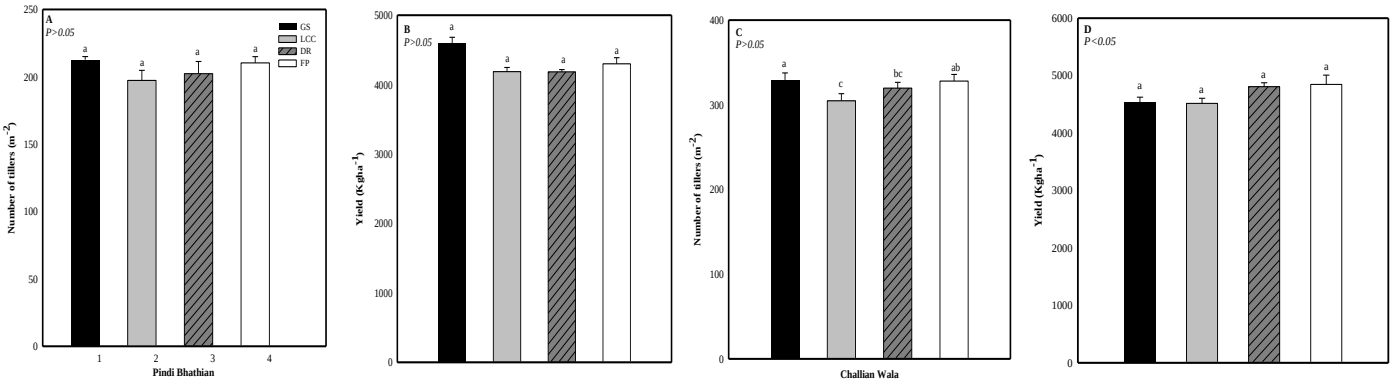
This study was conducted to evaluate different N management techniques in rice-wheat cropping system of Gujranwala Zone, Punjab-Pakistan. The study was accomplished during Kharif 2019-2021 at Adaptive Research Farm, Gujranwala, Pakistan (32°12'15"N 74°13'48"E, 227 m above sea level). Prior to sowing, soil was analyzed for physico-chemical properties by collecting samples (depth 0-30 cm) and submitting in Soil and Water Testing Laboratory, Gujranwala. Soil texture was found heavy loam with 0.89% organic matter, 7.8 pH, 1.8 mS/cm electrical conductivity (EC), 0.05% total N, 11.1 mg/kg available P and 154 mg/kg available K. The treatments included nitrogen management techniques viz. Green Seeker/ normalized difference vegetation index (NDVI) readings, leaf color chart and departmental recommendations in comparison to the farmers' practice. The laying out of experiment was performed by using the randomized complete block design (RCBD) and replicating thrice. The area of net plot was maintained at 10 m × 18 m.

Nursery of rice variety Super Basmati was sown using treated seed @ 12.5 kg for nursery required for on hectare. Thirty days old nursery was transplanted manually in puddled soil having water standing (depth 5 cm). The spacing between plants as well as rows was sustained at 22.5 cm. The similar dose of Di-ammonium Phosphate (DAP) fertilizer @ 185 $kgha^{-1}$ and Murate of Potash @ 123 $kgha^{-1}$ were broadcasted in each treatment at the time of puddling. However in Green Seeker treatment (112-120 $kgha^{-1}$), Leaf Color Chart (150-153 $kgha^{-1}$), Departmental Recommendations (185 $kgha^{-1}$) and Farmer Practice (247 $kgha^{-1}$) of urea fertilizer was applied in the field. Pre-emergence herbicide butachlor @ 2 Lha^{-1} was applied in the rice field with the help of shaker bottle. Zinc fertilizer was applied @ 15 kg ha^{-1} ten days after transplantation of rice crop. Urea fertilizer applied in three equal splits after transplanting in rice crop in departmental recommendation treatment; however, in Green Seeker and Leaf Color Chart treatments, urea fertilizer was applied as per crop requirement/crop need (Iqbal et al., 2016; Cao et al., 2016). All the agronomic practices and plant protection measures were kept constant.

Data regarding number of tillers and yield of rice was recorded at maturity. The crop was harvested from one m^{-2} area from each replication. The number of tillers was counted and yield was determined by threshing the samples and weighing. The cost of all the inputs and income was calculated according to the prevailing market prices. The benefit cost ratio was recorded by the formula given by Kahloon et al. (2012). The differences between the treatments were determined by analysis of variance keeping in view significant difference (*P>0.05*) through SPSS 13.0 (SPSS Inc., Chicago, IL, USA) and data presented through graphical representation by sigma plot 14 software (Iqbal et al., 2020; Iqbal et al., 2021).

Results and Discussion

Number of tillers m^{-2} showed non-significant (*P>0.05*) results in all treatments however yield data also showed non-significant (*P>0.05*) results at Pindi Bhattian during 2017 (Figure 1A & 1B). Non-significant (*P>0.05*) number of tillers m^{-2} recorded in GS (329 m^{-2}) which was at par with FP (328 m^{-2}) but recorded significant (*P>0.05*) results with LCC (304m^{-2}) and DR (319m^{-2}). Non-significant (*P>0.05*) yield was found in all treatments at Challian wala during 2017 (Figure 1C & 1D). Non-significant (*P>0.05*) number of tillers m^{-2} recorded both in GS & LCC but recorded significant (*P<0.05*) tillers with FP & DR. Significant (*P>0.05*) yield was found in GS (2860 $kgha^{-1}$) and LCC (2760 $kgha^{-1}$) compared to DR (2480 $kgha^{-1}$) and FP (2230$Kgha^{-1}$) at Phalia (Figure 1G & 1H).



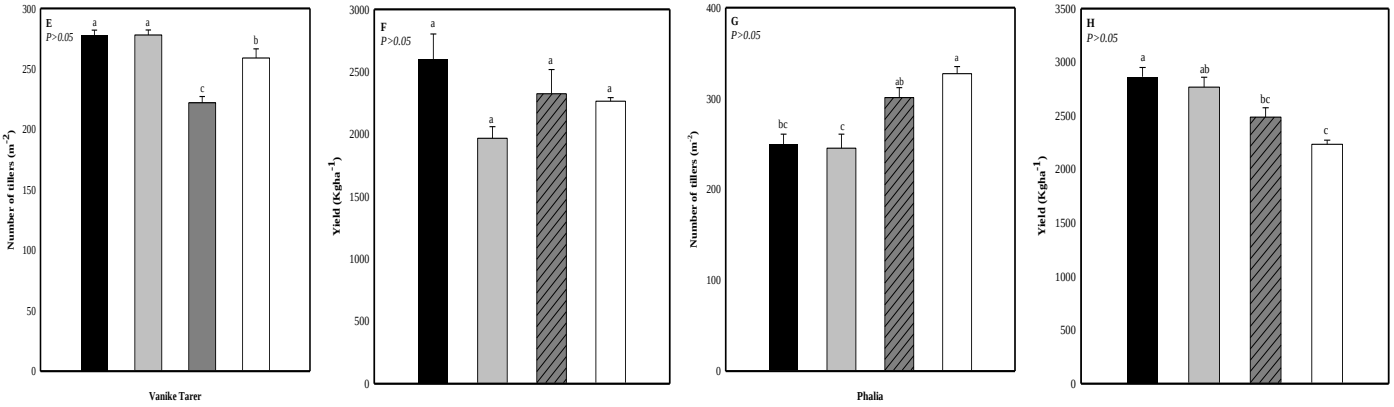


Figure 1 showing the impact of nitrogen management by using different techniques for cultivation of rice crop during 2017

Number of tillers m^{-2} showed non-significant (*P>0.05*) results in all treatments except GS (294 m^{-2}), however, yield data also showed non-significant (*P>0.05*) results at Mangat Neecha during 2018 (Figure 2A & 2B). The LCC recorded highly significant (*P<0.05*) number of tillers m^{-2} compared to rest of the treatments at Raikay but yield recorded non-significant (*P>0.05*) results during 2018 (Figure 2C & 2D). Statistically significant (*P<0.05*) number of tillers m^{-2} and yield recorded both in LCC treatments compared to all others treatments under observations. Similar number of tillers and yield data was recorded at Bilal Pur in the studied vicinity during 2018 (Figure 2G & 2H).

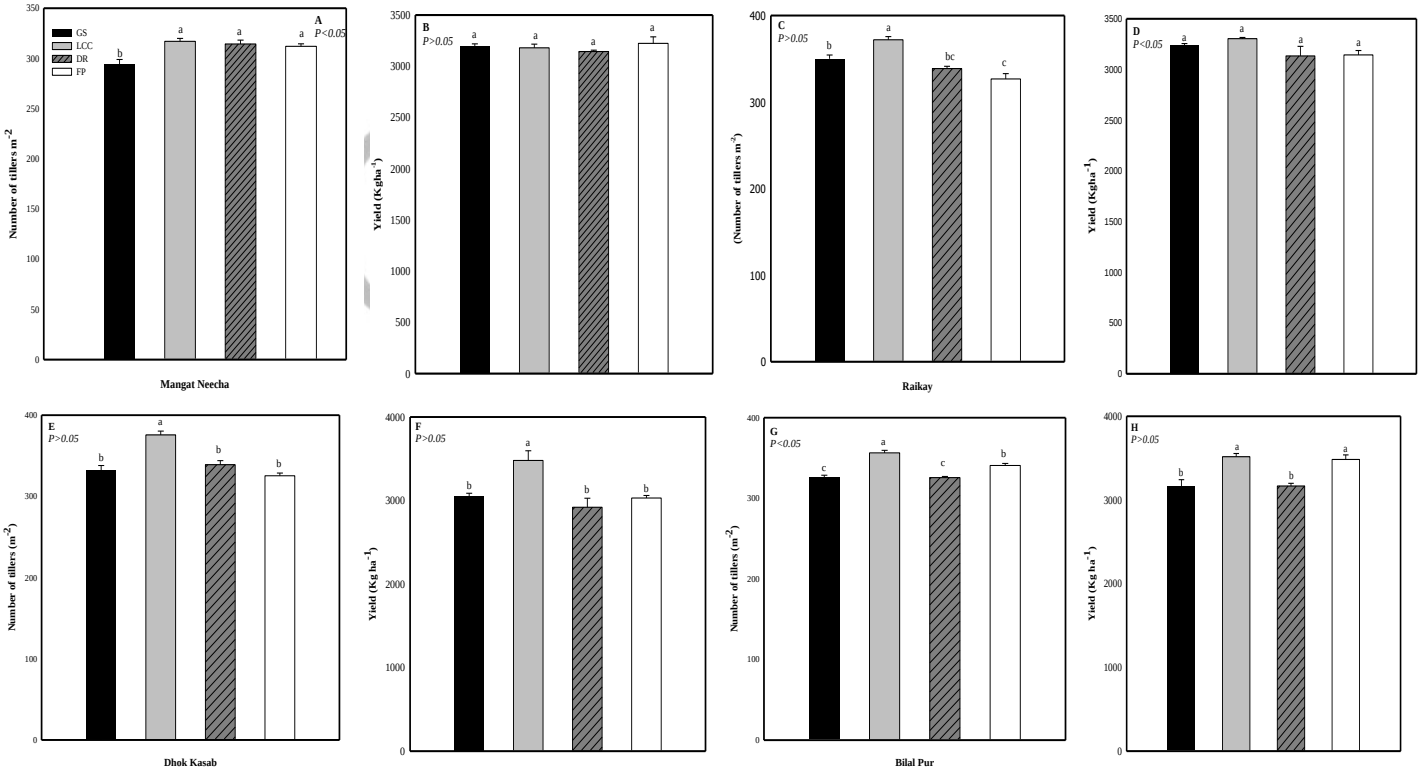


Figure 2 showing the impact of nitrogen management by using different techniques for cultivation of rice crop during 2018

Number of tillers m^{-2} showed non-significant (*P>0.05*) results in all treatments. Green Seeker and LCC found non-significant results (3843 $Kgha^{-1}$ & 3753 $Kgha^{-1}$) compared to DR (3487 $Kgha^{-1}$) and FP (3353 $Kgha^{-1}$) at Kotli Mano Sidhwan (District Gujranwala) during 2019 (Figure 3A & 3B). At Nandipur, significant number of tillers were recorded in GS, LCC and DR treatments compared to FP (303m^{-2}) however yield data recorded non-significant (*P>0.05*) investigations in GS (4070 $kgha^{-1}$) and LCC (4153 $kgha^{-1}$) treatments compared to DR (3623 $kgha^{-1}$) and FP (3097 $kgha^{-1}$). Number of tillers m^{-2} showed non-significant (*P>0.05*) results in all treatments compared to FP (238 m^{-2}) however similar trend was observed in all treatments compared to FP (4450 kg ha^{-1}) at Kot Saad Ullah (Figure 3E & 3F). The number of tillers were non-significantly (*P>0.05*) different with each other at Raikay (Figure 3G). The yield data showed non-significant (*P>0.05*) results in DR (4877 $kgha^{-1}$), LCC (4413 $kgha^{-1}$) and GS (4437 $kgha^{-1}$) but found significant (*P<0.05*)

yield compared to FP (3717 kgha^{-1}) at Raikay during 2019 (Figure 3H).

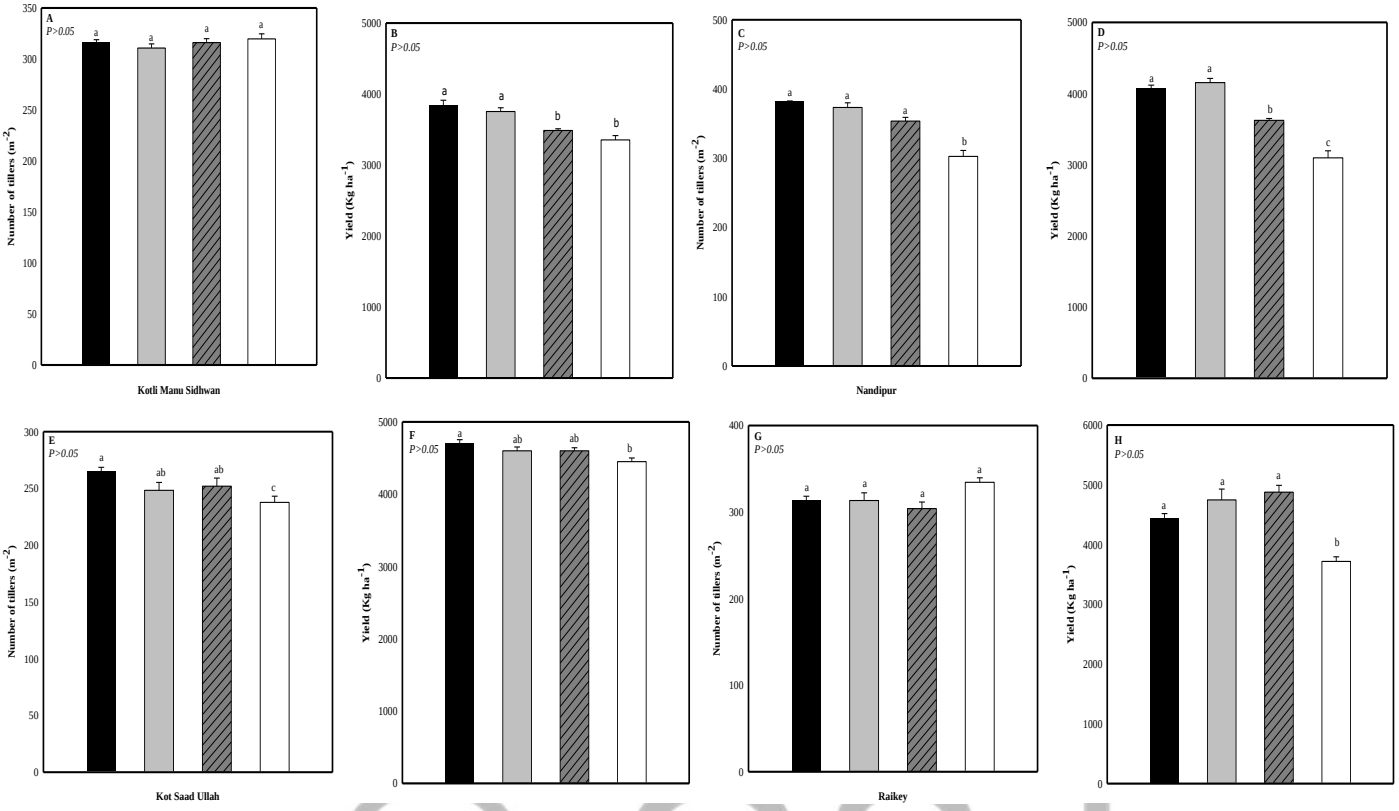
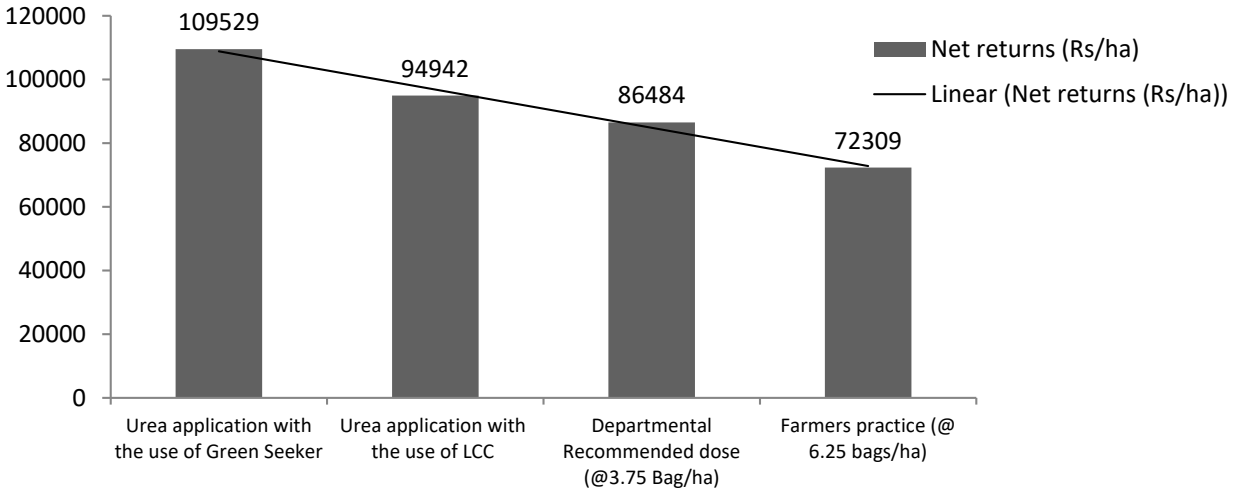


Figure 3 showing the impact of nitrogen management by using different techniques for cultivation of rice crop during 2019

Maximum net return was recorded Rs. 109529 ha^{-1} by the urea application with the use of GS with maximum BCR (2.02) followed by LCC (Rs. 94942 ha^{-1}) with BCR (1.88). Most of the places in our experiment DR and FP produced maximum yield due to high usage of nitrogen fertilizer application. The scientists reported that precision land leveling, precision planting, nutrient management by using GS, LCC, site specific nutrient management has a lot of potential for enhancing crop yield and input use efficiency under field conditions while reducing the cost of production and deleterious impacts on environment (Kumar et al., 2017; Purba et al., 2015).



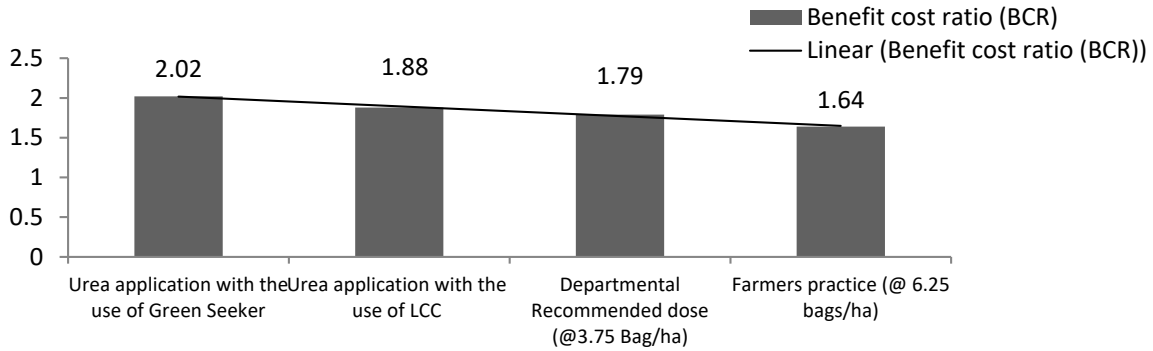


Figure 4 showing the economic impact of nitrogen management by using different techniques for cultivation of rice crops

The NDVI readings at panicle initiation growth stage exhibited the highest coefficient of determination and explained 63% of the variation in rice grain yield (Ali et al., 2014; Mohanta et al., 2021). Our results are in accordance to the scientists who reported that GS directed nitrogen application recorded maximum grain yield (5500 kgha^{-1}) followed by LCC (5200 kgha^{-1}), however, by using GS 45 kg N ha^{-1} was reduced. Our results are in line with the researchers who reported that the benefit cost ratio was found to be highest (2.76) with GS which also was statistically at par with LCC (2.45) and SPAD (2.32) and lowest with control (0.72) (Kumar et al., 2021). Our results are in line with the researchers who reported that N application with GS showed better performance in terms of saving a large amount of nitrogen fertilizer compared to control (Baral et al., 2021).

Conclusions

It is concluded that Green Seeker (GS) is an easy to use and cost effective technique for monitoring nitrogen requirement and effective in improving N fertilizer management in transplanted rice compared to LCC and other treatments. The GS helped farmers to estimate plant N demand without compromising the rice yield. The GS could be used to save nitrogen fertilizers, obtain better yield of rice and economic benefits.

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