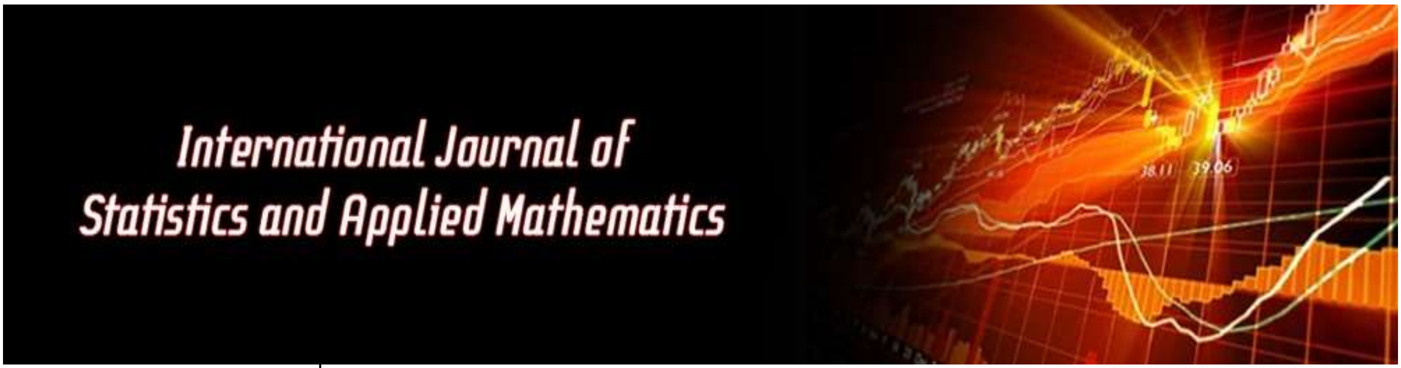

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A Review on response of various nitrogen levels and plant density on green forage yield, quality and economics of makkhan grass (*Lolium multiflorum* L.)

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Abstract
Effect of various nitrogen levels and seed rate on forage yield and quality of makkhan grass (*Lolium multiflorum* L.) revealed that sowing of makkhan grass with increasing levels of seed rate recorded significantly higher dry matter and green forage yield owing to significant increase of growth attributes over the lower levels of seed rate. The quality parameters *viz*., nitrogen and crude protein content significantly increased while ADF and NDF significantly decrease with decrease in levels of seed rate. The higher gross return, net return and benefit cost ratio was observed when crop was sown with higher seed rate than lower doses of seed rate similarly increase in nitrogen levels recorded significantly higher dry matter, green forage and crude protein yield. Regarding the quality parameters *viz*., nitrogen content in plant, crude protein content, cell content and ash content increased while ADF and NDF content of makkhan grass decrease with increasing levels nitrogen at all cuttings during both the years of experiment.

Keywords: Makkhan grass, seed rates, nitrogen levels

1. Introduction

Makkhan Grass is a non-leguminous forage crop exist both annual (*Lolium multiform* L.) and perennial (*Lolium perenne* L.) varieties is a native plant in Europe and widespread to North America, Africa and Australia. The plant height of makkhan Grass various 10-40 cm and depend on the various crop production factor like atmospheric humidity, solar radiation, wind velocity, soil moisture and fertility status of a growing area. Currently, increased growing area and demand of makkhan grass due to its rapid growing capacity, high forage yielding ability, energy rich and nutritional forage. It is considered to be one of the highest-quality winter forage crops. makkhan grass is highly nutritious multi-cut annual and perennial grass, highly succulent and the most palatable grass in the world. It's feeding will greatly improve milk production and quality specially milk solids fats. The concentration of dry matter digestibility is generally greater than 65% and crude protein exceeds the requirement for most classes of livestock. It has enabled the farmers to get cut-rate, appetizing and healthful forage during scarcity period of early winter and summer. It is perhaps the cheapest source of increasing milk production and superiority. The production of makkhan grass is not being fully exploited because of the lack of proper information about forage crops. Excessive runoff leading to soil erosion and nutrient loss could be effectively checked through its dense foliage capacity and development/restoration of degraded soil.

The country accounts for 10.7% of world's livestock population (529.7 million) with only 2.3% of the world's geographical area, 1.5% of forest and pasture land and 4.2% of water resources (Palsaniya *et al*., 2012) [30]. In India, the area under fodder cultivation is estimated to be about 4% of the total gross cropped area which has remained static for the last four decades because of preferential need for human food. At present, fodder demand is about 851.3 million tonnes green and 530.5 million tonnes dry but availability is about 590.4 and 467.6 million tonnes, respectively. It means presently, the country faces the net deficit of 35.6% green fodder, 10.95% crop residue and 44% concentrate feed ingredients (Anonymous 2015) [6].

Among the different forage production factors, fertilizer application rate and time is one of the most important factors in limiting the production of forage crops. Indian soils have generally been reported to be low in nitrogen, phosphorus and sulphur (Ramamurthy and Bajaj, 1969) [7].

Seed is a basic agriculture input and it is an embryo, embedded in the food storage tissue. The amount and its quality provide most essential component for enhancing the production and productivity of the crops. It is concerned with maintaining the desired plant population in a giving area in order to obtain highest profitable and quality yield of produce.

2. Effect of Nitrogen levels

2.1 Growth and yield of makkhan grass

Singh (1991) reported that application of nitrogen at an increasing rate, increases the total green fodder yield significantly at all cuttings except between N_{60} and N_{90} in 1st and 5th cut. Phosphorus application only significantly found up to 50 kg per hectare over control.

Albayrak, and Güler (2005) [4] study the effects of four nitrogen rates (0, 50, 100 and 150 kg ha^{-1}) on forage yield and some yield components of four perennial ryegrass (Lasso, Tetramax, Tivoli and Tove) and reported that the nitrogen levels significantly affect most of the yield components which were determined in perennial ryegrass. Forage yield and quality increased along with increase in nitrogen doses. Nitrogen fertilizer also increased the crude protein content in all cultivars. The highest forage, dry matter and crude protein yields were obtained from cultivar tove (12.90, 4.25 and 0.44 t ha^{-1}, respectively) in the treatment of 150 kg per hectare nitrogen.

Kusvuran (2011) [23] reported that the effect of different nitrogen doses on the herbage (150, 230, 310, 390, 470, 550, 630 and 710 kg ha^{-1}) and seed yields (150, 170, 190, 210, 230, 250, 270 and 290 kg ha^{-1}) of and some agricultural characteristics of annual ryegrass cv. “caramba” during the growing seasons of 2003-2004 and 2004-2005 in Turkey. As a result, the highest green forage yield of annual ryegrass (54976 kg ha^{-1}) was obtained at 550 kg ha^{-1} nitrogen levels. It was obtained for the seed production that the highest plant height (71.9 cm), number of tiller (626 m^{-2}), fertile tiller number (483 m^{-2}), spikelet number per grain is (32.7), the highest seed yield (343 kg ha^{-1}) were obtained from 250 kg ha^{-1} nitrogen application from the nitrogen dose application. In the light of information, the highest values were obtained from 470 kg ha^{-1} nitrogen application in herbage production and 250 kg ha^{-1} in seed production.

Park *et al.* (2017) [31] studied the comparative nitrogen use efficiency of urea and pig slurry for regrowth, yield and nutritive value in perennial makkhan grass and reported that the significantly positive effect of nitrogen fertilization on herbage yield, N recovery in herbage, residual inorganic N in soil and crude protein while no effect on neutral detergent fiber content, acid detergent fiber content and *in vitro* DM digestibility.

Bora (2020) studied the effect of nitrogen levels on green forage yield of the ryegrass and found the highest green forage yield (102.20, 135.31 and 143.89 q ha^{-1}) with the application of 90 kg nitrogen ha^{-1} at 1st, 2nd and 3rd cuts, respectively which was significantly higher than all other lower doses of nitrogen *viz*., 60 kg ha^{-1} (N_2), 30 kg ha^{-1} (N_1) and 0 kg ha^{-1} (N_0). The green forage yield observed at 90 kg N ha^{-1} was 234.4%, 122% and 103.9% higher than control at 1st, 2nd and 3rd cut, respectively.

Bolke *et al.* (2019) [9] evaluated the different levels of nitrogen (0, 150, 250, 350, and 450 kg N ha^{-1}) in the pasture and reported that the growth in the zero nitrogen pasture lasted 167 days with only three cuts, whereas in pastures treated with 350 and 450 kg N ha^{-1}, growth was extended for an additional 45 days with a 333% increase in the number of cuts. The pastures were used for the same duration (188 days) in the treatments with 150 and 250 kg N ha^{-1}, however, increased nitrogen resulted in two additional cuts and a shorter time interval between cuts. The time interval between each cut and the degree-days interacted dynamically causing distinct growth. Growth of the annual ryegrass BRS Ponteio without nitrogen application is poor and cannot be represented even by a first-order linear model. The application of nitrogen top dressing decreases the time interval between cuts, increases the dry matter production per hectare and stimulates this production.

Cinar *et al.* (2019) tested the effect of seven nitrogen rates (0, 50, 100, 150, 200, 250, 300 kg ha^{-1}) on makkhan grass and found the highest plant height (86.7cm) at 200 kg ha^{-1} of the nitrogen rate, highest fresh forage yield (48360 kg ha^{-1}) and dry matter yield (13325 kg ha^{-1}) with the application of 250 kg nitrogen per hectare. Thus, 250 kg ha^{-1} nitrogen rate was the optimum dose for high forage yield. Nevertheless, application of 300 kg ha^{-1} of nitrogen decreased yield.

Sidhu *et al.* (2020) [40] reported that annul makkhan grass produced significantly higher total green and dry forage yields with the application of 160 kg nitrogen per hectare under sowing time of 2nd fortnight of October.

Sarma *et al.* (2020) [35] revealed that application of 90 kg nitrogen per hectare in three splits as 40% basal + 30% after first cut + 30% after second cut produced the highest fodder yield with economic returns. The increase in total green fodder yield due to application of 30, 60 and 90 kg nitrogen per hectare over 0 kg nitrogen per hectare was 50.5, 59.0 and 64.8 per cent, respectively. The corresponding increase in total dry matter yield was 24.7, 33.0 and 38.3 per cent.

Sidhu *et al.* (2020) [40] reported that the annual ryegrass sown during the 2nd fortnight of October applied with 0 to 160 kg nitrogen per hectare and reported the 160 kg nitrogen per hectare gave highest total green and dry forage yield of 662.52 q ha^{-1} and 136.37q ha^{-1} than all other treatment combinations.

Bohn *et al.* (2020) [8] evaluate the effect of different levels of self-seeding Italian ryegrass and nitrogen levels applied additionally after two defoliations on plant structure, in forage and seed yield. Levels of self-seeding were classified as very high (777 kg ha^{-1}), high (736 kg ha^{-1}), intermediate (624 kg ha^{-1}), and low (234 kg ha^{-1}). Populations were fertilized with zero, 20.25, 40.50, and 60.75 kg ha^{-1} of supplemental nitrogen applied after two defoliations; respectively, in very high, high, intermediate, and low levels. Higher levels of self-seeding promoted greater forage yield and uniformity of vegetation structure. Number of fertile tillers and number of seeds per plant have benefited by the combination of high self-seeding and supplemental nitrogen fertilization. Despite influencing the uniformity and amount of forage obtained in two defoliations, the very high and low self-seeding levels did not differ in Italian ryegrass seed production.

Silveira *et al.* (2020) [41] tested nitrogen rates (0, 50, 100, 150, 200, 250 and 300 kg ha^{-1}) on the persistence of ryegrass forage production and reported that the application of nitrogen on natural re-sowing ryegrass promotes the increase in dry biomass production across agricultural years. The use of nitrogen as top dressing showed little effect on the persistence of ryegrass plants. The efficiency of nitrogen utilization was inversely proportional to the increment of the nitrogen doses used.

Viljoen *et al.* (2020) [49] reported that the herbage yield was determined through cutting herbage to a height of 30 mm above ground level from five randomly placed rings (0.0985 m^2) per plot, prior to grazing. The total annual herbage production of 23.48 t DM ha^{-1} $year^{-1}$ was the highest ($p < 0.05$) for the N_{80} treatment but did not differ from that of the N_{60} treatment, for which a herbage production of 22.94 t DM ha^{-1} was recorded.

Sandana *et al.* (2021) [34] reported that the higher nitrogen rates positively related to the forage dry matter yield and nitrogen concentration, but lower nitrogen rates resulted in higher NUE than higher nitrogen rates.

MS Sidhu *et al.* (2021) [39] studied the effect of sowing dates and nitrogen levels on growth and development, forage yield and economics of annual ryegrass and reported that the significantly higher plant height, tillers per square metre and dry matter accumulation of annual ryegrass was observed under 2nd fortnight of October sown crop with combined the application of 160 kg nitrogen per hectare resulted in significantly better plant height, tillers per meter square and dry matter accumulation of annual ryegrass.

2.2 Quality of makkhan grass

Sonia (1999) [44] reported that level of nitrogen application give an appreciable increase crude protein in all the cuttings. Maximum crude protein observed with highest rate of N application (90 kg ha^{-1}). Phosphorus application also improved the cure protein content in all the cuttings.

Albayrak and Güler (2005) [4] study the effects of four nitrogen rates (0, 50, 100 and 150 kg ha^{-1}) on forage yield and yield components of four perennial ryegrass (Lasso, Tetramax, Tivoli and Tove), and reported that the increasing levels of nitrogen fertilizer increase the crude protein content in all cultivars. The highest forage, dry matter and crude protein yields were obtained from cultivar Tove (12.90, 4.25 and 0.44 t ha^{-1}, respectively) with the application of 150 kg nitrogen per hectare.

Varella *et al.* (2010) studied the effect of four varying level of nitrogen (0, 50, 100, and 200 kg ha^{-1}) at different location and observed the maximum accumulation of dry yield (7.2 t ha^{-1}) at Embrapa, (6 t ha^{-1}) at UFRGS & (6.4 t ha^{-1}) Unicentro, under the application of 200 kg ha^{-1} nitrogen per hectare.

Bumane (2010) [11] reported that nitrogen fertilizer mostly influenced on herbage yield and quality characteristics of perennial ryegrass where both, crude protein content of dry matter and total yield of CP per hectare increased. In the treatments N_{60} and N_{120}, the CP content in grass dry matter increased by 0.14 and 2.66% and CP yield per hectare increased by 98 and 226%, respectively, compared with application of 0 kg nitrogen per hectare.

Kusvuran (2011) [23] reported that the effects of different nitrogen doses (150, 230, 310, 390, 470, 550, 630 and 710 kg ha^{-1}) on protein content and yield, observed the highest crude protein ratio (21.2%) and crude protein yield of (1982 kg ha^{-1}) with the application of 470 kg nitrogen per hectare in annual ryegrass cv. "caramba" during the growing seasons of 2003-04 and 2004-05 in Turkey.

Conagham *et al.*, (2012) [14] reported that the increasing nitrogen application levels from 0 to 120 kg per hectare tended to increase crude protein content (129.75 to 212.0 g kg^{-1} DM), buffering capacity (33.65 to 45.02 cmol kg^{-1} DM), dry matter yield (2.64 to 3.99 t ha^{-1}) but decrease the WSC (218 to 140.5 g kg^{-1} DM), dry matter concentration (185 to 135.25 g kg^{-1}), nitrogen use efficiency (22.62 to 11.12 kg DM kg^{-1}) and apparent nitrogen recovery (857.75 to 651.00 g N kg^{-1}) with little effect on DMD (827 to 807 25 g kg^{-1}) and ash content (101 to 114.25 g kg^{-1} DM).

Pavinato *et al.* (2014) [32] observed that the significant and linear effect of nitrogen fertilizer application on crude protein and dry matter yield.

Abraha *et al.* (2015) [1] conducted an experiment on application of nitrogen as top dressing after each harvest at the rate of 0, 30 and 60 kg nitrogen ha^{-1} and observed that the production of annual makkhan grass can be improved by using proper irrigation and nitrogen scheduling methods. The yield significantly increases as a function of the high amount of nitrogen fertilizer (60 kg nitrogen ha^{-1}) applied with higher irrigation compare other lower doses of nitrogen and water stress.

Çolak, and Sancak (2016) [13] reported that the increasing levels of nitrogen fertilizer increase plant height, stem diameter, fresh and dry hay yield. Significant differences were detected among yield characters of Italian rye grass herbage. In order to get higher forage yield in the Italian ryegrass cultivation in Ankara conditions, 8 kg da^{-1} nitrogen fertilizer is recommended.

Loaiza *et al.* (2017) [24] evaluate the effects of defoliation and nitrogen application rate (0, 75, 150, 300, 450 kg N ha^{-1} $year^{-1}$) on herbage carbohydrate and crude protein fractions and the water-soluble carbohydrate-to-protein ratio (WSC: CP) in perennial ryegrass swards and reported that the sward defoliation at two-leaf stage increased the total CP, reduced the buffer-soluble CP fractions and decreased carbohydrate fractions of herbage (*p*<0001). The effect of defoliation frequency was less marked during early spring and autumn (*p*<0001) than for the rest of the seasons. An increase in N application rate was negatively associated with WSC, crude protein fraction and neutral detergent fibre (*p*<0001), and positively associated with CP and nitrate ($N\text{-}NO_3$) contents of herbage.

Cinar *et al.* (2019) concluded that the highest crude protein yield (1870 kg ha^{-1}) and digestible dry matter yield (48360 kg ha^{-1}) was obtained with the application of 250 kg nitrogen per hectare. Over the other doses (0, 50, 100, 150, 200, 300 kg ha^{-1}) of applied nitrogen and the highest digestible dry matter rate (62.72 percent) was determined at the 150 kg ha^{-1} of nitrogen rate. Thus, nitrogen rate did not affect the ADF and NDF rate.

Akdeniz, H., *et al.* (2019) [3] applied five levels of nitrogen (0, 2, 4, 6 and 8 kg da^{-1}) Italian ryegrass and reported that the increasing rate of nitrogen fertilizer increase the green herbage as well as dry biomass yield of Italian ryegrass. The highest green herbage and dry biomass yield were recorded for the 8 kg N da^{-1} (1142.7 and 473.7 kg da^{-1}) treated grass followed by those treated with a 6 kg N da^{-1} (1070.2 and 444.8 kg da^{-1}). Similarly, the maximum seed yield was also recorded in the treatment of 8 kg N da^{-1}, followed by 6 kg N da^{-1}.

Sidhu *et al.* (2020) [40] reported that the annul makkhan grass produced significantly higher crude protein content (12.24 percent), crude Protein Yield (12.15 q ha^{-1}) and NPK content (2.03, 0.54 and 2.09 percent respectively) The uptake (201.14, 24.47 and 199.54, respectively). The significantly minimum neutral detergent fiber (41.76 percent) content was recorded with the application of 160 kg nitrogen per hectare.

Sekhar *et al.* (2020) observed that the application of 90 kg nitrogen ha^{-1} on makkhan grass resulted in to significantly

superior all quality parameters *viz*., crude protein yield (7.43 q ha^{-1}), crude fiber (12.74 percent) and crude fat content (3.68 percent) compare to all other levels of nitrogen 0, 60 and 30 kg nitrogen per hectare.
Godlewska *et al.* (2020) [19] reported that the application of nitrogen from 0 to 120 kg ha^{-1} significant reduced the amount of neutral detergent fiber and acid detergent fiber but increase the plant dry matter digestibility.
Singh *et al.* (2020) reported that the CPC and CPY increased significantly and consistently with increasing levels of nitrogen up to 160 kg nitrogen per hectare. The significantly highest values of CPC (12.24 %) and CPY (12.15 q ha^{-1}) were observed with the application of 160 nitrogen per hectare.
Olsezewka (2021) studied the effect of cultivar, nitrogen rate and harvest time on makkhan grass and reported that the increase in nitrogen fertilizer rate up to 240 kg per hectare contribute to a decrease in water soluble carbohydrate concentration and significantly increased the crude protein content both dry and wet basis.
Ertekin *et al.*, (2022) [16] reported that the effects of nitrogen doses on dry matter, neutral detergent fiber, acid detergent fiber, dry matter digestibility, relative feed value, crude protein, pH, ammonia nitrogen, lactic acid, acetic acid, and lactic acid/acetic acid were statistically significant while water soluble carbohydrate, ash and organic matter were not differ significantly. Ammonia nitrogen, crude protein, ash, organic matter, lactic acid, and lactic acid/acetic acid were affected by cultivars, but the other parameters were remained unchanged.

2.3 Economics
Godar *et al.*, (2016) [18] studied the effect of different nitrogen levels on forage yield, quality and economics of oat in Hisar and they reported that among the different nitrogen levels (40, 80,120 kg ha^{-1}) maximum gross return (69645 Rs ha^{-1}), net return (41785 Rs ha^{-1}) and B: C ratios 1.48 were observed with application of 120 kg nitrogen per hectare.
Bora (2018) reported that the application of nitrogen levels (0 to 90 kg ha^{-1}) the highest net return and B: C ratio Rs. 48777 ha^{-1} and 1.59, respectively was recorded with 90 kg nitrogen per hectare.
Sheoram *et al.*, (2017) [37] studied the agronomic evaluation of oat genotypes for forage yield, quality and economics under different nitrogen doses (40,80,120 kg ha^{-1}) and they reported that the use of nitrogen at the rate of 120 kg ha^{-1} recorded the higher gross return (38625 kg ha^{-1}), net return (10245.5 kg ha^{-1}) and B:C ratio (1.36) per hectare. Sidhu *et al.*, (2018) studied the effect of nitrogen application from 40, 80, 120 kg ha^{-1} and they reported the highest net return (48341 Rs ha^{-1}), gross return (76894 Rs ha^{-1}), B: C ratio 2.69 followed by net return (45126 Rs ha^{-1}), gross return (73198 Rs ha^{-1}), B: C ratio 2.61 per hectare associated with 120 kg nitrogen per hectare. Sidhu *et al.*, (2021) [39] reported that the annual ryegrass produced significantly highest total green, dry forage yields vis-a-vis net returns (Rs. 98937.30 ha$^{–1}$) and BC ratio of 2.97 were obtained under sowing time of 2nd fortnight of October. Application of nitrogen (160 kg N ha$^{–1}$) resulted in significantly highest total green and dry forage yields, net returns and B: C ratio. Shital *et al.* (2022) [38] reported that the, *rabi* fodder *viz*., Oat, Rye grass and Berseem grown with increasing the fertilized does 100 to 150 per cent their respective doses recorded better growth and yield than lower levels of nitrogen levels. In Oat, Rye grass & Berseem the more plant height (108, 56 & 53 cm), tillers per square meter (368, 381 & 411), Leaf Area Index (LAI 3.36, 1.83 & 0.62), Leaf: Stem ratio (1.63,4.22 & 0.62), Green fodder yield (GFY 353.61, 282.63 & 430.61 q ha^{-1}), dry fodder yield (DFY 113.7, 57.52 & 79.69 q ha^{-1}) and Per day productivity (3.21, 2.57 & 3.91 q ha^{-1}day^{-1}) were observed with 150 % recommended nitrogen.

3. Effect of seed rate levels
3.1 Growth and yield of makkhan grass
Kusvuran and Tansi (2011) [23] reported on the effects of different row spacing (sprinkle planting, 15, 20, 25, 30, 35, 40 and 45 cm row spacing) on the herbage and seed yields of and some agricultural characteristics of annual ryegrass cv. Caramba and reported the different row spacing significantly affect the herbage and hay yields, crude protein rate and yield, seed yield, tiller number and its proportion, spike length and spike weight. As a result, 30 cm row spacing resulted in to 80754 kg ha^{-1} herbage and 14932 kg ha^{-1} hay and 235 kg ha^{-1} crude protein yields. Venuto *et al.* (2004) [48] studied on the impact of seedling rate on annual makkhan grass performance at louisina with four seedling rates and reported that no advantage in total yield from increasing seedling rates beyond 800 PLS m^{-2}, because stem per plant decrease as seedling rate increase. However, first harvest yields increased from 360-930 kg dry matter per hectare as seedling rate increased from 400-1600 PLS m^{-2}. Meena *et al.* (2017) [25] reported that sowing of makkhan grass with 14 kg seed ha^{-1} gave significantly higher green fodder yield (879 q ha^{-1}) and dry fodder yield (178 q ha^{-1}) over berseem sowing by giving green fodder yield (690 q ha^{-1}) and dry fodder yield (142 q ha^{-1}.) however, sowing of makkhan grass with 13.0 and 15.0 kg seed ha^{-1} were at par with each other but it was found significantly superior over 12.0 and 16.0 kg seed per hectare. Bora (2020) [10] reported that the effect of seed rate levels on green forage yield of the rye grass was found significant at all the three cuts. The highest green forage yield of 84.03 q ha^{-1}, 118.27 q ha^{-1}and 128 q ha^{-1} were recorded in case of 20 kg ha^{-1} seed rate in all the three cuts *viz.*, 1st cut, 2nd cut and 3rd cut, respectively. The reduction of green forage yield at 10 kg ha^{-1} seed rate was 36.0%, 29.29% and 26.8% at 1st, 2nd and 3rd cut, respectively compared to 20 kg ha^{-1} seed rate. Todorovi *et al.*, (2020) [47] studied on the impact of row spacing and seed rate on the production characteristics of the perennial makkhan grass cv. Naki and they observed that sowing makkhan grass in wider rows (35.5-50 cm) and lower seed rate (9 - 16 kg^{-1}) to give significant results on height of tiller, spike length and numbers of spikelet's per spike while shoot dry weight obtained better results by sowing in narrow rows (12.5 cm). Shital *et al.* (2022) [38] reported that the *rabi* fodder *viz* Oat, Rye grass and Berseem sowing with 25 per cent more seeds rate their respective doses recorded tallest plant (108, 56 & 53 cm), more tillers per square meter (368, 381 & 411), high Leaf Area Index (LAI 3.36, 1.83 & 0.62), Leaf: Stem ratio (1.63,4.22 & 0.62), green fodder yield (353.61, 282.63 & 430.61 q ha^{-1}), Dry fodder yield (113.7, 57.52 & 79.69 q ha^{-1}) and Per day productivity (3.21, 2.57 & 3.91 q ha^{-1} day^{-1}) oat, rye grass & berseem respectively.

3.2 Quality of Makkhan grass
Venuto *et al.* (2004) [48] studied the impact of seedling rate on annual makkhan grass performance at louisina in four seedling rates (400, 800, 1200 and 1600 PLS m^{-2}) based on the pure live seed and they reported that crude protein, neutral detergent fiber and *in-vitro* dry matter digestibility was not affected by seed rate. Bora *et al.* (2020) [10] revealed that the highest crude protein yield (6.21 q ha^{-1}.) was obtained with

seed rate of 20 kg ha^{-1} and was significantly superior to 15 and 10 kg ha^{-1}. The crude protein content, crude fat content, crude fiber content of the makkhan grass were also found to be significantly higher in seed rate of 20 kg ha^{-1}.

3.3 Economics

Bora (2020) [10] reported that the economic indices indicated that the highest net return of Rs 51253 ha^{-1} and B: C ratio of 1.58 was recorded under 20 kg ha^{-1} seed rate. Singh (2018) [42] reported that the economics of ryegrass influenced by different ryegrass genotype. The higher net return of Rs.78991 ha^{-1} from makhan grass genotype, which was Rs. 6,745 ha^{-1} and 23,344 ha^{-1} more than Punjab ryegrass-1 and Kashmir collection, respectively. Among seed rate ratio of crops, sole stand of ryegrass resulted in highest net returns of Rs.76967 ha^{-1} which was followed by the net returns of Rs.73458 ha^{-1} in 75:25 seed rate ratio of the crops. Treatments comprising of ryegrass + berseem having net return of Rs.69496 ha^{-1} realized Rs 22361 ha^{-1} more than sole berseem. Ningoji *et al.,* (2020) [28] studied on effect of seed rate on growth yield and economics of hydroponic fodder maize production at AICRP Bengaluru and they reported that the maximum net returns (144 Rs m^{-2}) and B:C ratio (2.0) under 2.50 kg seed m-^{2} compare 1.50, 1.75, 2.0 and 2.75 seed rate levels. Asif *et al.,* (2021) studied on the spatial arrangements and seeding rates (80,100 and 120 kg ha^{-1}) on bio mass productivity, nutritional value and economic viability of maize and reported that the maximum net earnings of US$ 567 with highest B: C ratio 2.39 through application of 100 kg seed per hectare.

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