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Evaluation of different levels of Nitrogen applied in various number of split doses on growth, yield, and protein content of *spring* maize (*Zea mays* L.)

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Abstract
One of these is maize (*Zea mays* L.) is major components of hybrid has a greater grain output with Nitrogen. To maximize the output potential of maize, it's crucial to use better cultivars and nitrogen (N) fertilizer. which can adapt to a variety of Agroclimatic conditions, is one of the most adaptable crops. Because of the highest potential-yield of any cereal and referred as the "queen among cereals" internationally. Since maize is a heavy feeder and needs enough nutrients to achieve greater yields, nutrient management is essential for maize production. The use of fertilizers and other soil amendments is maximized with the aid of proper nutrient management, which also increases soil fertility and prevents nutrient deficits and toxicities. A field study entitled "Evaluation of different levels of Nitrogen applied in various number of split doses on growth, yield, and protein content of *spring* maize (*Zea mays* L.)" during the Lenten season in 2022 at Lovely Professional University, Punjab. The experiment comprised with 3 N levels (N_{95}, N_{125}, N_{155} kg ha$^{1)}$ and 2 split doses (First irrigation+ Pre-Tasseling), 3 split doses (Sowing + Knee Height + Pre-Tasseling) and 4 split doses (Sowing+ First Irrigation+ Knee Height+ Pre-Tasseling) with 3 replications in (RBD) various N levels significantly affected the grain yield & plant height of maize. N levels and splits significantly affected the grain yield. There was an increase in grain yield with N_{155} kg ha^{1} with Four split doses (Sowing+ First Irrigation+ Knee Height+ Pre-Tasseling) as compared to control, N_{95}, N_{125}. Whereas application of N_{155} kg N ha^{1} results in a significant increase in straw-yield.

Keywords: Nutrient management, maize, nitrogen, significance, growth, yield, protein content

Introduction
One of the significant coarse cereal crops and a member of the poaceae family. Due to its It has greater genetic potential than other cereal crops and known as the "Queen of Cereals." Maize adapts to a variety of agroclimatic settings. After rice and wheat, maize is India's third most significant crop. On 9.38 m ha^{1}, maize is grown with production of 30.16 mt, according to the second advance estimate for 2020–21 (Gov. of India, 2020). It serves as the primary raw material for numerous products, including those made by paper, oil, alcoholic drinks, food sweetener, cosmetic, textile, and packaging industries. Among nations that cultivate maize, India ranks fourth in terms of area and seventh in terms of production contributing four percent and two percent, respectively, of the world's area and production. (Kumar *et al.*, 2011) [10].

Cross-pollinated non-tiller plants like maize have yellow grains because of a pigment called cryptoxanthin. The ideal germination temperature is 21 °c. Maize needs between 500 and 800 mm of water per hectare and is very vulnerable to water logging. The maize plant's seminal roots help to nourish seedling plants.

There are many various kinds of maize, including regular corn, baby corn, sweet corn, popcorn, excellent protein maize, fodder maize, and maize primarily used (more than 60%) as feed for poultry and cattle. While the remaining 16-20% of produced maize is used for industrial purposes as starch and biofuel and the remaining 17-20% is used directly as food (Joshi *et al.*, 2014) [7].

It is a branched panicle that bears pollen or staminate inflorescence. The style is a very long silky filament that carries a female hairy cluster known as silk. Maize is a monoecious plant with two different forms of inflorescence. Two crops of maize are grown in Punjab, and the female pistillate inflorescences, also known as the ear or cob, appear from a node approximately halfway up the stem. Maize is an annual C4 plant, and the male flower matures before the female flower. Heavy clay loam soils are more suited for their successful production.

Spring maize is the crop sown in January–February, whereas kharif maize is the crop sown in July–August.

In Indian soils, nitrogen (N) insufficiency is a common occurrence, and its appropriate management is essential from an economic and environmental perspective. For effective use, the right timing, technique, and optimal nitrogen (N) treatment must all be synchronised with crop needs. A lack of nitrogen can cause chlorosis, yellowing, stunted growth, and lower yields. Different agro-ecological zones require different rates and amounts of nitrogen. Up to a certain degree, N levels improve yield, but independent of plant density, the ideal economic nitrogen dose is determined. Nitrogen-containing fertilizers are frequently utilised, and Indian farmers are generating more of them in larger quantities. Nitrogen (N) is typically applied based on the plant's greenness and the colour of its leaves Fertilizers containing nitrogen are commonly used, Indian farmers are producing more in larger amounts, nitrogen (N) is usually applied based on the greenness of the plant, the colour of the leaves, a visual indicator of crop nitrogen (N) status One of the main problems affecting cereal production's ability to produce yield has been thought to be a N deficiency. (Shah *et al.*, 2003) [16]. The "no. of leaves plant^{1}, plant-height, leaf area index, leaf area duration, crop growth rate, and total dry matter" were all considerably improved by nitrogen application in three splits at the planting, V4- There is a fourth leaf collar and V6- there is a sixth leaf collar stages. application of different split doses in 3 rates of N (90, 120 and 150 kg N ha^{1}) with 4 split doses (50% sowing + 17% top dressing +17% at knee high and 17% at tasseling stage). 150 kg ha^{1} has resulted in higher plant-height, dry-weight, grain-yield. In comparison with nitrogen doses of 120 kg and 90 kg ha^{1} with 4 doses of splits (50 percent sowing, 17 percent at top dressing, 17 percent at knee height, and 17 percent at tasseling). Reddy and others, 2019. With nitrogen application timing T3 (195 kg ha^{1}) (1/3 in planting, 1/3 in 8 to 10 leaf stages and 1/3 at tassel initiation), the highest protein content (12.9%) was discovered. T2 (180 kg ha^{1} 1/2 at planting + 1/4 in 8 to 10 leaf stages + 1/4 at tassel initiation) and T1 (150 kg ha^{1} 1/2 planting + 1/2 in tassel initiation) were the next-highest nitrogen application timings. Nemati *et al.*, (2012) [12].

Material and Methods

The experiment was performed at the Lovely Professional University's agricultural research facility in Phagwara. To characterize the distribution of climatic zones in Punjab and Chaheru village in Kapurthala district, which is in the Northern plain zone between 31°N, 31.25^{0}N Latitude 75^{0}E Longitude in research area which has an average of 252m above mean sea-level in the northwest of India. Topographically, the farm had a medium slope and well irrigation facilities. There are three distinct seasons and a subtropical, semiarid climate. December, January, and February are the winter months that also have potential to experience rain. The crop-growing season was when the meteorological data was collected. Temperatures throughout the crop season reached highs of 38.4^{0}c and lows of 15.3^{0}c, respectively. During the experimentation period, the site had a subtropical environment with burning, humid summers, and severe winter. The experiment was designed as an RBD with three replications and ten treatments. Treatment included T_1: Control, T_2: N_{95} S_2, T_3: N_{95} S_3, T_4: N_{95} S_4, T_5: N_{125} S_2, T_6: N_{125} S_3, T_7: N_{125} S_4, T_8: N_{155} S_2, T_9: N_{155} S_3 and T_{10}: N_{155} S_4. P1899 variety were used which was released in 2019 with the average duration of 120 days and to assure the right plant population, seeds were hand spread using the "dibbling" method, with 60-20 cm between rows & plants, at a depth of 3-5 cm. Recommended dose of Nitrogen (N) 120 kg ha^{1}. Four randomly selected locations from the experimental field were sampled for representative soil at depths of 0 to 15 and 15 to 30 cm before experiment began, and a composite sample was made. The soil at the evaluation site was a standard sandy loam texture with reaction with pH 7.5 organic carbon content, nitrogen, phosphorous and potassium are being estimated 0.600%, 110 kg ha^{1}, 13.4 kg ac^{1}, 99.3 mg kg ac^{1} respectively. The P_2O_5 & K_2O applied as basal, according to recommended doses. All the agronomic and cultural procedures for the maize crop as specified in the PAU package procedures. Parameters for growth and yield were recorded as per standard procedures and evaluated statistically. (Plant height cm) was measured using measuring tape, No. of leaf plant^{-1} were counted, (leaf-area cm^{2}) was measured using (leaf area meter), The chlorophyll content was determined. with SPAD meter at 30, 60, 90 DAS and at harvest cob length was measured by scale, grain rows cob^{1}, grains cob^{1} were hand counted, (grain-yield kg ha^{1}) and (stover-yield kg ha^{1}) weighed and noted.

Statistical analysis

Using SPSS 22 software, the data was subjected to ANOVA using the Post Hoc, Tukey, and Duncan functions. Results were reported as means standard deviation and homogeneity of variance was adapted. (DMRT) mean approach was used with probability $p<0.05$ to determine the best effective treatment. The significance of the variation components was examined using As a Post-hoc test, use the Fisher's LSD test.

Result and Discussion

The findings from the research were presented in tables along with the appropriate statistical analysis in terms of growth, yield, and assessment studies.

Table 1: (Plant height cm) as influenced by various factors number of N split doses in maize at different growth stages.

Nitrogen	30 DAS	60 DAS	90 DAS	At harvest
T_1: Zero N (Control)	11.2	105.0	144.4	145.5
T_2: $N_{95}S_2$	11.3	134.9	169.2	170.0
T_3: $N_{95}S_3$	11.2	109.7	162.2	166.7
T_4: $N_{95}S_4$	11.0	125.0	167.2	167.3
T_5: $N_{125}S_2$	11.0	122.6	169.0	170.5
T_6: $N_{125}S_3$	11.1	108.0	158.9	165.3
T_7: $N_{125}S_4$	12.0	144.9	176.2	175.4
T_8: $N_{155}S_2$	11.2	121.7	177.6	177.1
T_9: $N_{155}S_3$	12.7	123.2	160.8	166.2
T_{10}: $N_{155}S_4$	11.6	120.2	167.7	172.8
LSD (0.05)	0.755	3.703	2.447	12.6

Growth attributes of maize: Plant growth is a result of multiple physiological and biological processes that are quantified in in terms of the rate of dry matter generation and its accumulation in diverse plants sections, which is then reflected in economic yield. The data Table 1 shows the data collected at (30, 60, 90, and at harvest DAS). At 30 DAS, increasing the N level and splitting the doses to 95 kg ha^{1}, they are on par with N 125 kg ha^{1} with four spilt doses, further increase to 155 with two split doses they are at par with 125 and 95 kg ha^{1} with four split doses, and further increase into three split doses with 155 kg ha^{-1} as significantly increased compared to N 155 kg ha^{1} with four split doses. At 60 DAS, application of N 125 kg ha^{1} with four split doses produced significantly higher plant height compared to all other split doses, further increases to 155 kg N ha^{-1} with four splits decreased plant height significantly. At 90 DAS, all split doses increased the plant height significantly as compared to zero. The higher plant height observed under N 155 kg ha^{1} with two splits which was at par with N 125 kg ha^{1} with four split doses and significantly higher compared to remaining all other treatments. At harvest, all splits were increased the plant height as compare to zero. The N application of 155 kg ha^{1} with two split doses increased the plant significantly, compared to control, 95, 125 kg ha^{1} with 2 splits doses. Harikrishna *et al.*, (2010) [5], Karkia *et al.*, (2020) [8] & Bhatnagar *et al.*, (2019) [4] fined that higher plant height with the N application of 150 kg ha^{1} with 4 schedule S4 (twenty percent basal, twenty percent at knee high, thirty percent at knee high, twenty percent at tasseling, ten percent at grain fullness) recorded higher plant height. Mahesh *et al.*, (2016) [11] Significantly N application of 300 kg ha^{1} enhanced the height of plant (176cm), it is par with 240 kg ha^{1} but had substantially taller plants (175 cm), than (180 &120 kg ha^{1}). Patel Upasana *et al.*, (2021) [13] concluded that N level of RDN 100% greatly enhanced the plant's height (220.3 cm) and when the RDN level was increased to 50 to 75% plant height failed to increase significantly (198.0, 208.1 cm).

Table 2: The effect of nitrogen levels on spring maize biological yield, stover yield, grain yield, and protein content.

Nitrogen (kg ha^{1})	Biological yield (t ha^{1})	Stover yield (t ha^{1})	Grain yield (t ha^{1})	Protein content (%)
T_1: (Control)	8.88^{f} ± 0.128	6.29^{c} ± 0.11	2.66^{c} ± 0.103	4.9^{e}
T_2: $N_{95}S_2$	15.31^{e} ± 0.343	8.26^{b} ± 0.27	6.60^{b} ± 0.108	5.0^{cd}
T_3: $N_{95}S_3$	15.46^{e} ± 0.801	8.77^{b} ± 0.08	6.65^{b} ± 0.766	9.2^{bc}
T_4: $N_{95}S_4$	15.69^{de} ± 0.281	8.70^{b} ± 0.15	6.93^{ab} ± 0.144	10.6^{ab}
T_5: $N_{125}S_2$	16.88^{abc} ± 0.113	10.27^{a} ± 0.30	6.70^{b} ± 0.186	7.8^{cd}
T_6: $N_{125}S_3$	16.83^{abc} ± 0.241	9.72^{a} ± 0.15	7.03^{ab} ± 0.115	9.1^{bc}
T_7: $N_{125}S_4$	16.30^{cd} ± 0.226	8.89^{b} ± 0.18	7.31^{a} ± 0.173	7.6^{cd}
T_8: $N_{155}S_2$	17.65^{a} ± 0.422	10.08^{a} ± 0.30	7.38^{a} ± 0.160	12.2^{a}
T_9: $N_{155}S_3$	16.56^{bc} ± 0.316	10.21^{a} ± 0.37	7.42^{a} ± 0.207	7.0^{d}
T_{10}: $N_{155}S_4$	17.39^{ab} ± 0.422	9.82^{a} ± 0.32	7.42^{a} ± 0.112	8.2^{cd}
LSD (0.05)	0.715	0.507	0.561	1.6

Effect on maize yield and yield characteristics

The economic yield of an any crop is the result of various linked Plant growth and development are characterized by physiological and biochemical processes. Development in response to light, temperature, water, and nutrients. The data of yield attributes & yield of spring maize *viz*., **(**Biological yield t ha^{1}), (Stover-yield t ha^{1}), Grain-yield (t ha^{1}) were presented in Table (2). when the N level increases to N_{155} with two split doses (S_2) increased the biological yield significantly compared to control. But it was at par with $N_{155}S_4$ $N_{125}S_3$, $N_{125}S_2$ and when N levels increased to $N_{155}S_3$ was at par with $N_{125}S_4$ and the least was recorded with control. These findings are in line with those of Varma *et al.*, (2022) [18] & Adhikari *et al*., (2021) [1] found that a N dose of 220 kg ha^{1} resulted in the maximum biological production (23.00 t ha^{1}) followed by 200 kg ha^{1} (21.82 t ha^{1}) and 180 kg ha^{1} (20.68 t ha^{1}). Similarly, the lowest biological yield in N was discovered to be 160 kg ha^{1} (18.14 t ha^{1}). After separating the grains from the plant's biomass, the stover yield was acquired and presented in table 2. Stover yield enhanced significantly with application $N_{95}S_2$ compared control but when N levels increases to N_{95} to N_{125} there is no significant increases in stover yield further increases to N_{155} with four split doses there is a significant increase in stover yield compared to control, $N_{95}S_2$, $N_{95}S_3$, $N_{95}S_4$ and $N_{125}S_4$ and the lowest was recorded with control. The output of stover increased as N levels increases was reported by Jena *et al*., (2013) there are similar findings were found with the research Bhatnagar *et al.*, (2019) [4] observed a significantly greater stover yield with the application of 150 kg ha^{1} in four schedules, namely, S4 (20 percent at basal, 20percent prior to knee high, 30percent at knee-high, 20percent at tasseling, and 10percent at grain formation) compared to 90,120 kg N ha. N levels have a major impact on grain output. (Table 2). Increasing level of N from 0 kg ha^{1} to 125 kg ha^{1} with two three and four spilt doses enhanced the Grain yield significantly. Grain yield was found highest in N 155 kg ha^{1} and 95 kg ha^{1} with four split doses, 125 kg N ha^{1} with three split doses were statically at par with $N_{95}S_4$. Similarly, lowest yield was observed under control similar with Begam *et al.*, (2018) [3], Stesi *et al.*, (2020) [17], Adhikari *et al.*, (2016) [2] increasing the N levels increased the grain yield substantially greater yield of grains (3911 kg ha^{1}) was achieved N application of (30 kg ha^{1}) (basal use, 30, 45, 60, and 75 days after sowing) and Rani *et al*. (2013) reported the same grain-yield (7951 kg ha^{1}) of these yield attributes than (200 kg ha^{1}) with 3 equal split doses “1/3 at basal, 1/3 at knee height, and 1/3 at tasseling” and the results of Khalili *et al.*, (2017) [9] Protein quantity in grain is a qualitative study, and protein content data was provided. The highest protein was with treatment $N_{155}S_2$ followed by lowest was with control.

Potential conflict of interest

The authors state that they do not have any conflicts of interest.

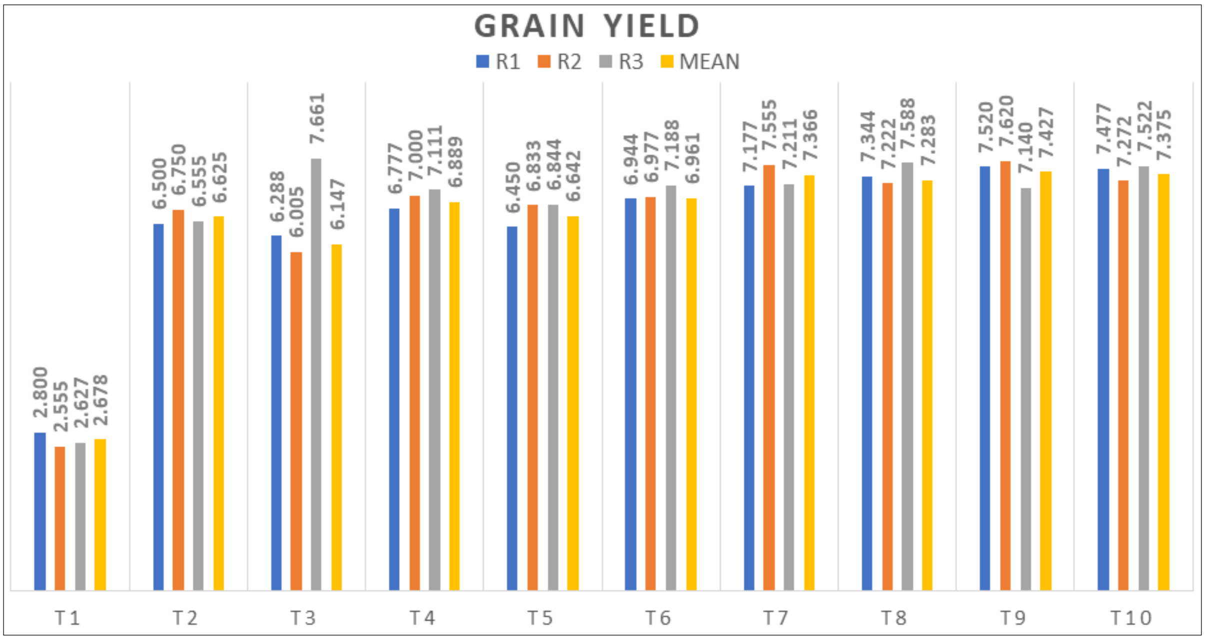

Fig 1: The interactive effect of varied N levels and split dosages on spring maize grain yield (t ha^{1}).

Conclusion and future thrust

It has been discovered that an increase in nitrogen dosage resulted in an increase in several yields and yield qualities "grain yield- stover yield, and biological yield". The maximum yield was 155 kg ha^{1}, which, statistically speaking, was comparable to 125 kg ha^{1}. The 155 kg N ha^{-1} and control groups showed the highest and lowest levels of positive connection between N levels and biometrical observations "plant height", respectively.

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