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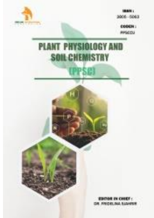

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RESEARCH ARTICLE

EFFECT OF ZINC AND BORON ON GROWTH AND YIELD OF MAIZE (*ZEA MAYS* L.) IN PYUTHAN, NEPAL

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ABSTRACT

The study was carried out to evaluate the production performance of hybrid maize variety Kanchan with the use of different fertilizers at field condition. The study was conducted with five treatments and four replications in single factor Randomized Complete Block Design. Treatment consists of farmer practice 80:50 NP_2O_5 kg ha^{-1}, recommended dose 150:60:40 $NP_2O_5K_2O$ kg ha^{-1}, recommended dose of $NP_2O_5K_2O$ + 15 kg ha^{-1} zinc, recommended $NP_2O_5K_2O$ + 2 kg ha^{-1} boron, and recommended $NP_2O_5K_2O$ + 15 kg ha^{-1} zinc + 2 kg ha^{-1} boron. At 90 days after sowing the leaf area index (LAI) was significantly higher with recommended dose of $NP_2O_5K_2O$ + Zn + B (2.46cm^2) which was statistically similar with recommended dose of $NP_2O_5K_2O$ + Zn (2.39cm^2) and recommended dose of $NP_2O_5K_2O$ + B (2.22cm^2). Plant heights were the highest with recommended $NP_2O_5K_2O$ + Zn+ B at earlier stage of crop growth but was statistically similar among different treatments at later stage of crop growth. Days to 50% tasseling were the longest with farmer practice (74 days) while it was shortest in recommended $NP_2O_5K_2O$ + Zn+ B (69days). Anthesis silking interval was obtained the shortest in recommended $NP_2O_5K_2O$ + Zn +B (2.75days). Similarly, phenological character, cob length was highest (16.650cm) with recommended $NP_2O_5K_2O$ + Zn+ B which was statistically similar with recommended $NP_2O_5K_2O$ + B (16.725cm) and recommended $NP_2O_5K_2O$ + Zn (16.5cm). The lowest sterility (%) was obtained with the recommended $NP_2O_5K_2O$ +Zn+ B (9.5%) which was statistically similar with recommended $NP_2O_5K_2O$ + B (9.5%) and Rec. NPK +Zn (11.2%). The highest grain yield (9.01ton/ha), harvest index (0.45) and benefit cost ratio (1.92) were recorded with the recommended $NP_2O_5K_2O$ + Zn+ B while these parameters were the lowest with the farmer practice. Thus, the study showed that hybrid maize yield could be maximized with fertilization of 150:60:40 $NP_2O_5K_2O$ kg ha^{-1}, Zn15 kgha^{-1} and B 2 kgha^{-1} and use of micronutrition such as Zn and B is beneficial to enhance growth and yield of hybrid maize.

KEYWORDS

Zinc, Boron, Hybrid Maize, Soil application, phenotypic, Yield, Benefit cost ratio

1. INTRODUCTION

Maize is the most produced cereal crop in the world. It is the most important staple food crop of Nepal after rice, which is grown in 30.87% of total cultivated land area (Upadhyay et al., 2020). Maize contributes 6.88% to AGDP of the country and it is regarded as an important crop insuring food security (CDD, 2015). Maize is grown throughout Nepal while major production occurs in mid-hills. Pyuthan district is one of the advanced and developing mid-hill districts of Lumbini Province. Total production of maize in Pyuthan district is 25,172 tons grown in 13,673 ha having productivity of 2.22 t ha^{-1} (MOALD, 2020). Majority of people cultivate maize in summer season (Feb to July), though it can be cultivated year-round. Comparing Pyuthan productivity (2.22 t ha^{-1}) with national average productivity 2.96 t ha^{-1}, the productivity of Pyuthan could be upgraded (MoALD, 2020). Major varieties of maize grown here are Manakamana-3, Arun -2 and local varieties.

Soil fertility is considered as the most important constraint to increase maize production in this district (Paudel et al., 2009). Zn exerts a great influence on basic plant life processes such as nitrogen metabolism-uptake of nitrogen and protein quality, photosynthesis, chlorophyll synthesis, carbon anhydrase activity, resistance to abiotic and biotic stresses, protection against oxidative damage. Boron is essential for many plant functions, including cell wall formation and stability, the structural and functional integrity of biological membranes, the movement of sugar or energy into plant growing parts, and pollination and seed set (Kumar et al., 2019). This report presents the effect of micro-nutrition zinc and boron application in hybrid maize variety Nutan (Kanchan, 101). The best time of planting for spring is mid-February in uplands of Terai (Ranum et al., 2014).

Low soil fertility status and improper and imbalance use of chemical fertilizers are the major factors influencing productivity of maize in Nepal (Ransom and Poudyal, 2002). A group researchers reported 58.12% farmer do not apply fertilizer (Paudel et al., 2009). Although spring season could be utilized for maize cultivation, Pyuthan district has poor practices of spring maize farming. Farmers of Pyuthan lack knowledge about economic commercial markets and importance of hybrid maize. Most people are confined to use FYM only in maize field. Management of FYM prior to ploughing is also unscientific and the nutrient supplied by FYM is not sufficient to exploit genetic potential of hybrid maize. Farmers lack knowledge about right rate, right method and right timing of fertilization.

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Mostly, farmers use urea or DAP as a source of inorganic fertilizer based on their availability in the market without much concern about the nutritional requirement of the maize. Farmers are reluctant to use new seed variety and mostly use seed from informal seed system. Moreover, traditional concept is used during land preparation like heaping of FYM in field 15 days prior to ploughing and use of wet manure. They apply fertilizer only once as a basal dose (Maize Annual Report, 2020). Lack of knowledge of improved crop management practices including fertilization, and choice of variety are other problems. There was large variation in maize productivity ranging from a minimum of 0.36 t ha^{-1} to a maximum of 5.13 t ha^{-1} the different agro-ecologies within the mid-hills. Almost no farmer used zinc and boron as micronutrition in their field.

Among the maize growing areas of Pyuthan district, Khapring-khola basin and Jhimrok-khoa basin are potential areas for maize production. Interest in producing an improved, hybrid and commercial Maize (*Zea mays* L.) in Pyuthan district has been growing steadily, due to the potentiality of higher economic returns as compared to local variety. The average yield of local maize in the mid-hill agro-ecology reported to be from 1.35 t ha^{-1} to 2.36 1.35 t ha^{-1} and that of hybrid maize to be from 3.23 to 5 t ha^{-1}. People are unaware about the selection of high yielding varieties, its management practices such as fertilizer management, sowing date, planting density. Basic research regarding management and fertilization in hybrid maize is needed which helps growers to be aware about economic and nutritional value of maize.

The status of spring hybrid maize production in Nepal is narrow, as farmers grow it in a subsistence way but maize demand in Nepalese market is increasing. A large amount of maize is consumed in feed, food manufacture, direct food, and bioethanol. Therefore, technological development regarding management and cultivation of the crop is necessary. It was reported that Nepal imports 400 thousand tons maize annually, to compensate this import maize cultivated area should be increase from 30% area coverage to 36% of cultivated land. This could be achieved by increasing winter and spring maize production, increasing production and productivity of maize by replacing local variety with improved one. Replacing the variety whose yield is less than 3 1.35 t ha^{-1} or increasing productivity of existing maize through timely supply of recommended dose of fertilizer (Upadhyay et al., 2020).

The overall scenario of problem among maize growers indicates towards determining the suitable dose of micro nutrition fertilizer in the maize yield. This study helps to demonstrate the farmers about the relative importance of cultivating spring maize on barren mid-hill. It will help to relate the phenological and yield attributing characters with proper application of N dose, Zn and B. It helps to relate the appropriate fertilization application $NP_2O_5K_2O$, Zn and B. Hybrid variety as the method to increase in yield, spring maize cultivation cause increase in production and appropriate nutrition management help in reducing yield gap. The increase of benefit cost ratio (B: C) through fertilizer management helps in fertilizer adoption on hybrid maize. So, this research is conducted to fulfill the yield gap due to lack of nutrient.

2. Methodology

The research site selected was Khapring-khola 8, Pyuthan municipality of Lumbini province Nepal. The field was located at 832 m above sea level.

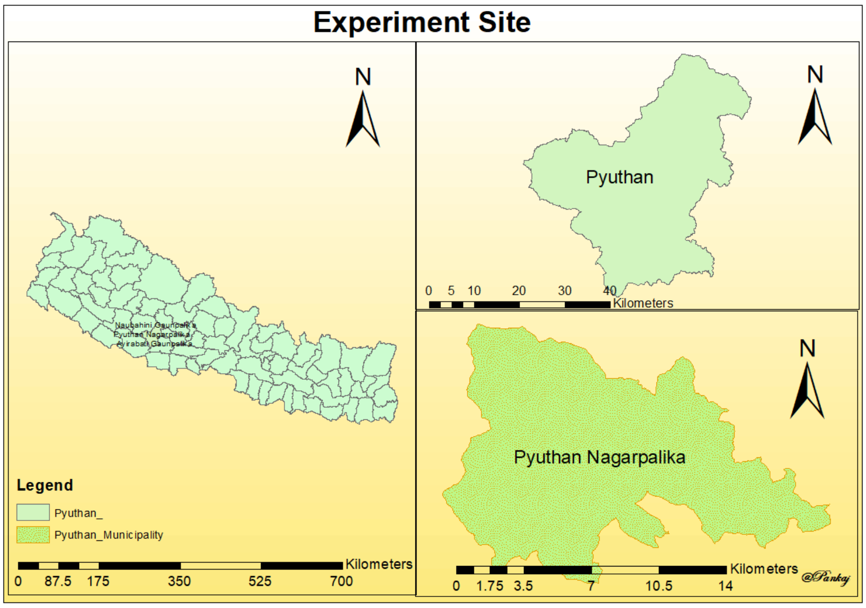

Figure 1: Map of Nepal showing Experimental site

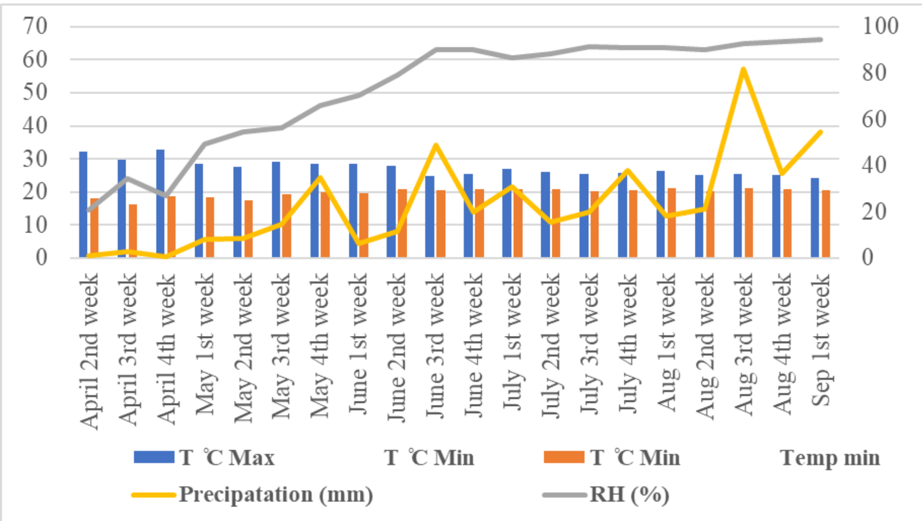

Figure 2: Weather data during the field experimentation at KhapringKhola, Pyuthan (Source: Power Nasa)

Table 1: Physio-chemical characteristics of soil from research site			
S. N	**Soil Properties**	**Values**	**Method used**
1.	Textural Class	sandy loam	Hydrometer (Estefan et al., 2014)
2.	Chemical properties		
a.	pH	6 (Acidic)	Beckman glass electrode PH meter (Pradhan, 2005)
b.	Nitrogen (%)	0.12 (Medium)	Kjeldhal distillation (Jackson, 1967)
c.	Phosphorus, P_2O_5 (kg ha^{-1})	62.67 (high)	Spectrophotometer (Olsen et al., 1954)
d.	Potash, K_2O (kg ha^{-1})	255.72 (medium)	Ammonium acetate method (Jackson, 1967)
e.	Organic Matter (%)	2.35 (low)	Walkey and Black method (Pradhan, 2005)
f.	Zinc	2.20ppm	Spectrophotometric method (Kumar et al., 2019)
g.	Boron	0.79ppm	Colorimetric assays (Kumar et al., 2019)

Before start of experiment, soil samples were taken from each replication by using shovel from 0 to 15 cm depth. Then sample was analyzed for soil properties as presented in table.

The experiment was conducted in Randomised Complete Block Design (RCBD) with five treatment and four replications. Treatments were laid perpendicular to replication. Five treatments were: *Treatment A*: Farmer practice: 80:50 Kg NP_2O_5 per ha, Treatment B: recommended dose: 150:60:40 kg $NP_2O_5K_2$ kg ha^{-1}, Treatment C: 150:60:40 $NP_2O_5K_2$ kg ha^{-1} +Zn 15kg ha^{-1} (soil application), For the treatment C the research was using the application of recommended dose of $NP_2O_5K_2$ along with 15kg ha^{-1} ZnSo4. Zn application has found increased in grain yield by 26% in maize across a wide range of environment of production (Haris et al., 2007). Treatment D: 150:60:40 $NP_2O_5K_2$ kg ha^{-1}+B 2kg/ha (soil application), based on field responses to B application, B deficiency has been reported in maize across five continents (Bell and Dell,2008).

Treatment E 150:60:40 $NP_2O_5K_2$ kg ha^{-1} + Zn15 kg/ha + B2 kg ha^{-1} (soil application),as research shown for maximum grain yield maize crop should be sown by supplying Rec. dose of NPK (150:75:75 kg ha^{-1}) along with ZnSO4 15kg ha^{-1},and borax 5 kg ha^{-1} (Shori et al., 2019). Nitrogen, phosphorous and potassium were supplied through urea, single super phosphate (SSP) and Muriate of Potash (MOP) containing 46% N, 16% P_2O_5 and 60% K_2O respectively. The recommended amount of Phosphatic and Potassic fertilizers 60:40 $kgha^{-1}$, were calculated and weighed separately for all treatment. The total amount of nitrogen (150kg ha^{-1}) for each plot was divided into three equal parts. Full dose of phosphorus and potassium and one third of Nitrogen were applied as basal dose 5 cm apart from maize row at 5 cm depth and second split dose of Nitrogen was applied as side-dress (top dress) at knee high stage and finally last dose was side dressed at tasseling stage.

2.1 Statistical Analysis

The data recorded on different parameters from field and laboratory were first tabulated in Microsoft Excel (MS- Excel), then Analysis of Variance (ANOVA) for all data was computed using RStudio computer software package. All the analyzed data were subjected to Duncan's Multiple Range Test (DMRT) for mean comparison at 5% level of significance.

2.2 Observation and Measurement

2.1.1 Biometrical Observations

Five plants were randomly selected and from which parameters were observed and measured.

2.1.2 Plant Height

The plant height was measured with the help of scale and measuring tape from the base of plant at ground surface to tip of the highest visible part at 45, 60, 75 and 90 DAS.

2.1.3 Leaf Area Index (LAI)

Linear dimensions (length and breadth) of fully opened leaf were recorded manually. And then, leaf area was computed using the equation suggested (Montegory, 1911). A = b*L*W, Where b = Leaf Shape Coefficient, A= Area, L=length and W = width. The coefficient was conventionally assumed 0.75 for maize leaf

Leaf Area Index (LAI) was computed by finding the ratio of leaf area to ground area. Leaf Area Index is an indicator of primary photosynthetic productivity and rate of evapo-transpiration in crop field.

Leaf area Index (LAI) =Area of leaves (canopy)/ Ground area under canopy

Ground area = 50*20 cm^2

2.3 Phenological Data

2.3.1 Days to 50% Tasseling

The date by which 50% plants in each plot had produced tassels was recorded as the dates of tasseling. After recording these dates for each plot, the days taken to 50% tassel was calculated by taking the difference of date of sowing and tasseling.

2.3.2 Days to 50% Silking

The date by which 50% plants in each plot had given silk was recorded as the dates of silking. After recording these dates for each plot, the days taken to 50% silking was calculated by taking the difference of date of sowing and silking.

2.3.3 Anthesis Silking Interval

Anthesis silking interval of maize was determined by the difference between tasseling and silking days. It was expressed in days.

2.3.4 Yield Attributing Characters

Ten plants were selected from each plot for taking measurement of yield and yield attributing character.

2.3.5 Number of Cobs/Plants

Total number of cobs/plants obtained from net plot harvested was divided by plant population to obtain total number of cobs/plants.

2.3.6 Cob Length

Length of the ear was measured and recorded in centimeters at the time of harvest as its total length (from the base to the tip of the ear). Ten representative cobs were taken from each plot and expressed in cm.

2.3.7 Number of Kernel Row Cob^{-1}

The Number of grain row of ten cob was counted and then averaged data was recorded as number of grain row per cob.

2.3.8 Number of Kernels Row^{-1}

The number of grains of five rows of each sampled ten cobs was taken and then averaged data was reported as number of kernels per row.

2.3.9 Thousand Grain Weight

The weight of sundried thousands grain samples drawn at randomly in each plot was recorded in grams at 15 percent moisture content.

2.4 Measurement of Yield

2.4.1 Grain Yield

The weight of grain from each plot was recorded. The data was converted and reported as grain yield as ton/ha. The moisture percentage of grains of each plot was determined by moisture meter and the final grain yield was adjusted at 14% moisture level by the following formula. The thousand grains weight was expressed in gram.

$$\text{Grain yield (Kg/ha) at 14\% moisture} = \frac{\text{(100-MC) * grain yield at actual moisture content}}{\text{(100-14)}}$$

Where MC= moisture content of the grain (Source: Mulvaney and Devota, 2020)

2.4.2 *Biomass Yield*

The harvested (Stover + Cob) is called biomass. The biomass yield was taken from net harvested area from each plot. The Stover was cut close to ground level and sun dried for few days. The biomass yield was converted into kg ha^{-1}.

2.4.3 *Harvest Index*

Harvest index in percentage was calculated by using following formula (Donald and Hamblin, 1976).

$$\text{HI (\%)} = \frac{\text{Grain Yield}}{\text{Biological yield}} * 100$$

2.5 Economic Analysis in Maize Cultivation

2.5.1 *Cost of Cultivation*

Cost of cultivation was calculated on the basis of expenses for different inputs as labor, fertilizer, land preparation, seed, intercultural operation costs, herbicides and insecticide, harvesting and threshing. These costs were indicated as variable costs, and the land rent was considered as the fixed cost

Total cost (TC) = Total Fixed Cost (TFC) + Total Variable Cost (TC)

2.5.2 *Gross Return*

Economic yield (grain + stover) was converted to gross return (NRs. ha^{-1}) on the basis of local market prices of different commodities.

Gross Return = Return from Grain Yield + Return from Stover

2.5.3 *Benefit-Cost Ration (BCR)*

The BCR was estimated as dividing the gross return by the total cost of cultivation.

$$\text{B: C ratio} = \frac{\text{Gross Return}}{\text{Total Cost of Cultivation}}$$

3. Result and Discussion

3.1 Leaf Area Index

At, 30days after sowing (DAS) the highest leaf area index (LAI) was obtained recommended $NP_2O_5K_2O$ + Zn +B ($0.26cm^2$) followed by recommended $NP_2O_5K_2O$ +Zn($0.20cm^2$), recommended $NP_2O_5K_2O$ +B ($19cm^2$) whereas, the lowest leaf area index was seen in farmer practice ($0.14cm^2$) and recommended $NP_2O_5K_2O$ ($0.18cm^2$). Similarly, at 45DAS the highest leaf area index was recorded with recommended $NP_2O_5K_2O$, Zn +B ($1.57cm^2$) and least leaf area index was obtained in recommended $NP_2O_5K_2O$+B ($1.97cm^2$) which was statistically similar recommended with $NP_2O_5K_2O$+Zn ($1.13cm^2$), recommended $NP_2O_5K_2O$($0.96cm^2$) and farmer practice ($0.88cm^2$). While no significant different in leaf area index was obtained among the treatment at 60DAS. At 75DAS recommended $NP_2O_5K_2O$+ Zn +B ($3.53cm^2$) showed the highest leaf area index followed by recommended $NP_2O_5K_2O$ +Zn ($3.3cm^2$) while least leaf area index was recorded in recommended $NP_2O_5K_2O$ ($2.58cm^2$) which was statistically similar with farmer practice ($2.69cm^2$).

Leaf area index at 90 DAS was the highest at recommended $NP_2O_5K_2O$ +Zn +B ($2.46cm^2$) which was statistically similar with recommended $NP_2O_5K_2O$ +Zn ($2.39cm^2$), recommended $NP_2O_5K_2O$ +B ($2.22cm^2$.) while least was recorded with recommended $NP_2O_5K_2O$ ($1.92cm^2$) and farmer practice ($1.88cm^2$). It might be due to longer maturity duration of leaf with good photosynthesis in recommended $NP_2O_5K_2O$ +Zn +B while least in farmer practice might be due to early aging and senescence. The obtained result is in agrees with the finding of Zn and B causes significant different in leaf number which cause increase in leaf area index but B had no significant different in leaf number (Soomto et al., 2011). Some researchers reported that there is significant different in the wideness, length of leaf by the application of Zn and B (Bature, 2018).

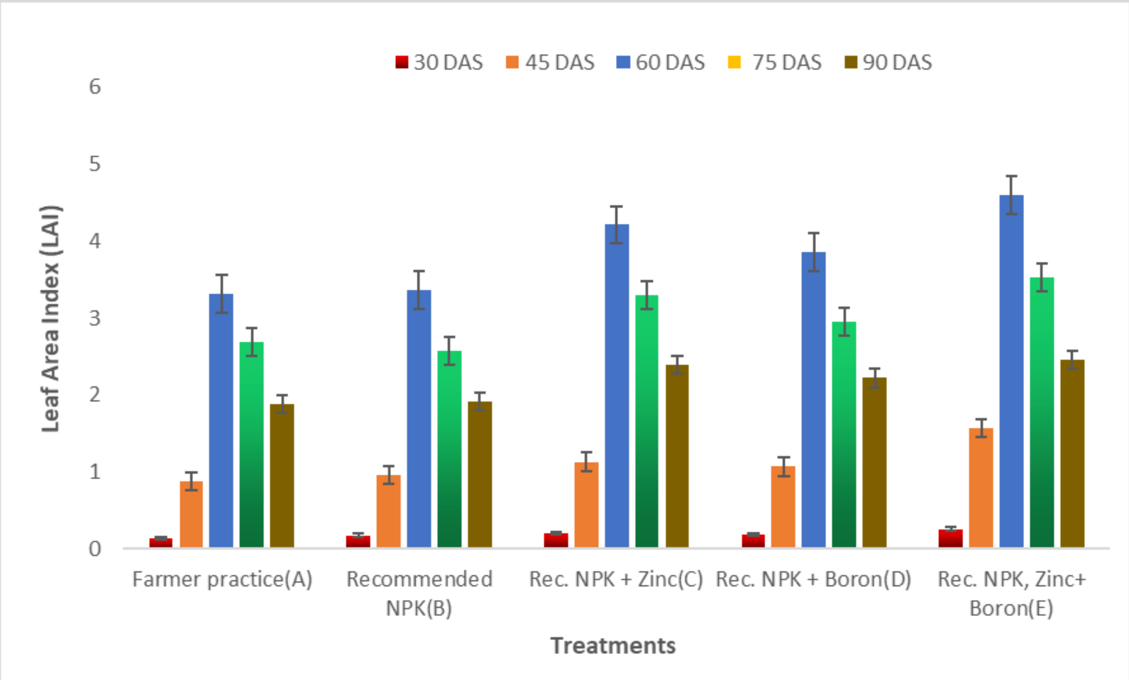

Figure 3: Leaf area index as influenced by the application of different nutrient

3.2 Plant Height

At,30days after sowing (DAS) the highest plant height was obtained in recommended $NP_2O_5K_2O$+ Zn+ B (23.15cm) followed by recommended $NP_2O_5K_2O$ + B (21.15cm) which was statistically similar with the recommended $NP_2O_5K_2O$ +Zn (20.35cm) and recommended $NP_2O_5K_2O$ (20.25cm) whereas lowest height was obtained with the farmer practice(17.9cm). Similarly, at 45DAS highest plant height was obtained with recommended $NP_2O_5K_2O$, Zn +B (66.75cm) which was followed by recommended $NP_2O_5K_2O$ +Zn (58.15cm) and recommended $NP_2O_5K_2O$ +B (57.60cm) whereas with farmer practice (46.50cm) lowest height was obtained followed by recommended $NP_2O_5K_2O$ (46.50cm). At 60DAS,75DAS and 90DAS no statistical different in plant height was obtained among the treatment. This might be due to the plant height as a plant varietal character.

The above result are in line with finding of who recorded the significant different in the height of the plant in the early stage of growth (Bature, 2018). While no statistical different in plant height in the late stage of the plant. A researcher reported Zn don't show significant effect in plant height in late stage of plant, instead 70% zinc uptake in late stage of plant is directed to reproduction in maize (Tariq, 2014). Zinc effect shows substantial different in all physiological and yield except plant height and stem diameter. A group researchers reported the plants which received soil-applied boron at 2 kg ha^{-1} had plant height of 190.67 cm Whereas, minimum plant height 187.37 cm was recorded in control where no boron was applied (Soomro et al., 2011). It means very few effects in plant height is seen due to B application. Also in other research, author has reported that B has significant effect on grain yield and the number of grains per ear than the effect on plant height (Rerkasem and Dell, 2021).

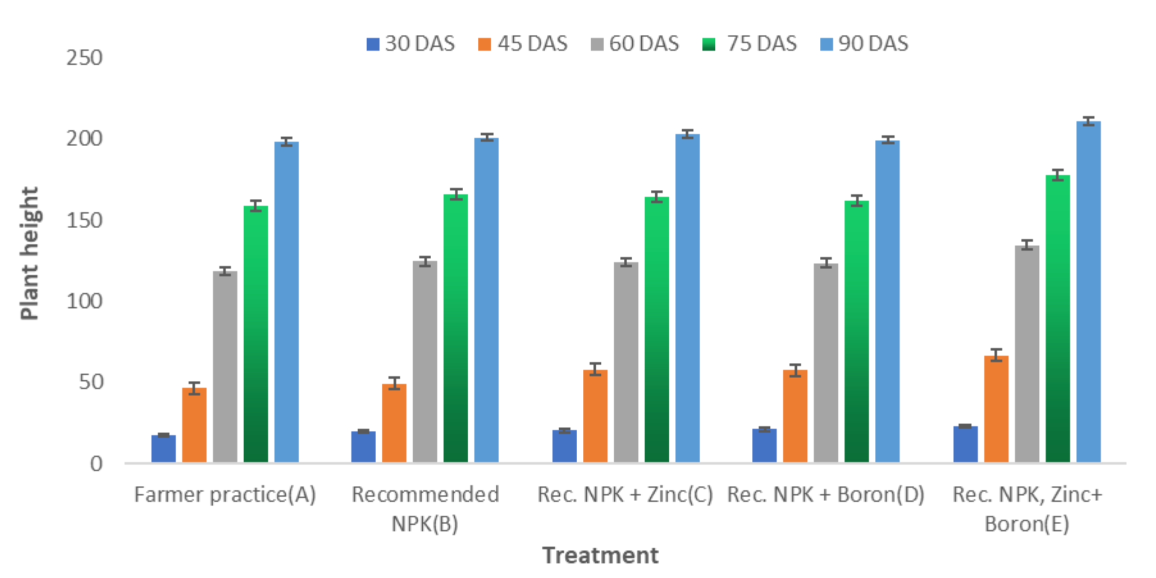

Figure 4: Plants height influenced by the application of different plant nutrients

3.3 Phenological Observation

3.3.1 Days to Tasseling, Silking and ASI

Maximum days to 50% tasseling is found in farmer practice (74days) which was followed by recommended $NP_2O_5K_2O$ +B (73.50days) and recommended $NP_2O_5K_2O$ (74days) whereas minimum days was obtained with recommended $NP_2O_5K_2O$ + Zn +B followed by recommended $NP_2O_5K_2O$ + Zn. Similarly, maximum days to silking is recorded with farmer practice (78.5days) followed by recommended $NP_2O_5K_2O$ (78.5days) and recommended $NP_2O_5K_2O$ +B (76.88days) while minimum days of silking was obtained with recommended $NP_2O_5K_2O$ +Zn +B (71.75days) which was statistically similar with recommended $NP_2O_5K_2O$ + Zn (75.75days).

Maximum anthesis silking interval (ASI) was obtained with farmer practice (4.5days) which was statistically similar with recommended $NP_2O_5K_2O$ (4.2days) followed by recommended $NP_2O_5K_2O$+ B (3.78days) and recommended $NP_2O_5K_2O$ +Zn (3.5days) while least anthesis silking interval (ASI) was recorded with recommended $NP_2O_5K_2O$ +Zn +B(2.75days). Lower the anthesis silking interval greater will be the pollination duration so obviously, recommended $NP_2O_5K_2O$ +Zn +B has better pollination. The above result are in line with the finding of who reported more than 70% of Zn and 65% of B uptake occurs during late vegetative and early reproductive growth which helps in fast maturity of tassel and silk which causes decrease in anthesis silking interval (Stewart et al., 2021). A researcher reported sexual reproduction in plant is more sensitive to B deficiency than vegetative growth, B deficiency depresses commercial corn yield primarily through grain set failure (Aref, 2011).

Table 2: Maize phenological observation as influenced by the application of different plant nutrients

Treatments	Phenological observations		
	Days to Tasseling	**Days to Silking**	**ASI (days)**
Farmer Practice(A)	74^{a}	78.5^{a}	4.5^{a}
Recommended NPK(B)	72.75^{ab}	77^{ab}	4.2^{a}
Rec. Npk + Zinc(C)	71.5^{b}	75.75^{c}	3.5^{b}
Rec. Npk + Boron(D)	73.50^{ab}	76.88^{ab}	3.78^{bc}
Rec. Npk, Zinc+ Boron(E)	69.0^{c}	71.75^{c}	2.75^{c}
Sem (±)	0.3	0.36	0.1
Lsd (=0.05)	2.1	2.45	0.71
Cv%	1.89	2.1	12.54
F-Probability	<0.01	<0.001	<0.01
Grand Mean	72.15	75.82	3.678

Mean followed by common letter(s) within columns are non-significantly different based on DMRT P=0.05, Sem: Standard error of mean, CV: Coefficient of variance, LSD: least significant different, DAS: days after sowing, LAI: leaf area index

3.3.2 Influence on Cob Length, Sterile Length and Sterility Percentage

Cob length was obtained highest with the recommended $NP_2O_5K_2O$ +B(16.725cm) which was statistically similar with recommended $NP_2O_5K_2O$ +Zn +B(16.650cm) and recommended $NP_2O_5K_2O$+ Zn(16.50cm) whereas lowest cob length was obtained with the recommended $NP_2O_5K_2O$ (15.525cm) and farmer practice(15.150cm). Similarly, sterile length was obtained highest with the farmer practice(2.47cm) which was statistically similar with recommended $NP_2O_5K_2O$(2.46cm) whereas lowest sterile length was obtained with the recommended $NP_2O_5K_2O$ +Zn +B(1.57cm), recommended $NP_2O_5K_2O$ +B(1.60cm) and recommended $NP_2O_5K_2O$ +Zn(1.84cm). While highest sterility% was obtained with the farmer practice (16.27%) and recommended $NP_2O_5K_2O$ (15.8%) whereas lowest sterility% was obtained with the recommended $NP_2O_5K_2O$ +Zn +B (9.5%) which was statistically similar with recommended $NP_2O_5K_2O$ +B (9.6%) and recommended $NP_2O_5K_2O$ +Zn (11.2%).

The above results are in line with who observed lack of Zn decreases pollen viability and leads to pollen sterility in maize and then to low kernel numbers (Sharma et al., 1990). A group researchers reported Zinc application likely promoted pollen grain development, and pollen viability at tasseling stage (Stanley and Linskens, 2012; Liu et al., 2020). Zn application significantly increased pollen viability at the tasseling stage.

3.4 Yield and Yield Attributes

Highest number of cobs per plant was obtained with the recommended $NP_2O_5K_2O$ +Zn +B (2.1) which was followed by recommended $NP_2O_5K_2O$ + Zn (1.9) and recommended $NP_2O_5K_2O$ +B (1.63) whereas lowest number of cobs per plant was obtained with the recommended. $NP_2O_5K_2O$ (1.5) which was statistically similar with farmer practice (1.5). Similarly, Row number cob^{-1} was obtained highest with the recommended $NP_2O_5K_2O$ +Zn +B (15.85), which was statistically similar with the recommended. $NP_2O_5K_2O$ +Zn (15.8) and recommended. $NP_2O_5K_2O$ +B (15.52) followed by recommended. $NP_2O_5K_2O$ (14.5) and farmer practice (14.7). Grains row^{-1} was obtained highest with the recommended. $NP_2O_5K_2O$ +Zn +B (35.85) followed by recommended $NP_2O_5K_2O$ +B (33.65) which was statistically similar with recommended.

$NP_2O_5K_2O$ + Zn (33.55) while lowest grains row^{-1} was obtained with the farmer practice (30.80) which was followed by recommended $NP_2O_5K_2O$ (32.30). Similarly, highest grains yield was obtained with the recommended $NP_2O_5K_2O$+Zn +B (9.01t ha^{-1}) followed by recommended $NP_2O_5K_2O$ + Zinc (8.20 t ha^{-1}) which was statistically similar with the recommended $NP_2O_5K_2O$ +B (7.99 t ha^{-1}) while lowest grains yield was obtained with the farmer practice (6.52ton/ha) which was followed by recommended $NP_2O_5K_2O$ (7.11t ha^{-1}). The effect of Zn, B their effect on N_2 use efficiency increase grain feeling duration as plant attain tasseling stage earlier and go for senescence late cause maximum yield in recommended $NP_2O_5K_2O$ +Zn +B. Similarly, Harvest index was found highest in recommended $NP_2O_5K_2O$ +Zn +B (0.45) followed by recommended. $NP_2O_5K_2O$ + Zn (0.44) which was statistically similar with recommended $NP_2O_5K_2O$ +B (0.43) while, lowest harvest index was found with the farmer practice (0.38) followed by recommended $NP_2O_5K_2O$ (0.40).

The above results are in line with the finding of who reported that Soil application of Zn fertilizer increased grains yield by 4.2 to 16.7% of maize by improving pollen viability, kernel number, and kernel weight of inferior grains (Liu et al., 2020). Sole effect of potassium was found non-significant for grain yield but in interaction with phosphorus levels and maize varieties potassium produced better yield. Also, observed lack of Zn decreases pollen viability and leads to pollen sterility in maize and then to low kernel numbers and yield (Sharma et al., 1990). Similarly, observed potassium application on maize gave more no. of grains row-1, no. of grains cob-1 and higher grains weight cob-1 (Adnan, 2020). Zn is a micronutrient which enhances the grain productivity in the maize production Similarly, B application improves growth, and enhances stress tolerance in plants and improves grain production. Khourgami and Fard reported seed yield, 1000-grain weight and harvest index were higher in case of zinc applied treatments (Khourgami and Fard, 2012)

Table 3: Cob length, sterile length and sterility percent as influenced by the application of different nutrient.

Treatment	Cob Length (cm)	Sterile Length (cm)	Sterility %
Farmer Practice(A)	15.150^{b}	2.47^{a}	16.27^{a}
Recommended NPK(B)	15.525^{b}	2.46^{a}	15.8^{a}
Rec. Npk + Zinc(C)	16.500^{a}	1.84^{b}	11.2^{b}
Rec. Npk + Boron(D)	16.725^{a}	1.60^{b}	9.6^{b}
Rec. Npk +Zinc +Boron	16.650^{a}	1.57^{b}	9.5^{b}
Sem (±)	0.098	0.058	0.375
Lsd (=0.05)	0.678	0.4	2.587
Cv%	2.73	13.07	13.467
F-Probability	<0.001	<0.001	12.47
Grand Mean	16.11	1.987	<0.001

Table 4: Yield and yield attributes as influenced by the application of different nutrients

Treatment	Yield attributes				
	No. of Cob/Plant	**Row Num/Cob.**	**Grain Per Row**	**Grain Yield(ton/ha)**	**Harvest Index**
Farmer practice	1.5^{c}	14.7^{b}	30.80^{c}	6.52^{c}	0.38^{c}
Recommended NPK	1.5^{c}	14.5^{b}	32.30^{bc}	7.11^{bc}	0.40^{bc}
Rec. NPK + Zinc	1.9^{ab}	15.8^{a}	33.55^{ab}	8.20^{ab}	0.44^{ab}
Rec. NPK + Boron	1.63^{bc}	15.52^{a}	33.65^{ab}	7.99^{ab}	0.43^{ab}
Rec. NPK, Zinc + Boron	2.1^{a}	15.85^{a}	35.85^{a}	9.01^{a}	0.45^{a}
Sem (±)	0.046	0.137	0.357	0.154	0.0054
LSD (=0.05)	0.318	0.106	2.46	1.016	0.037
CV%	11.905	3.13	4.81	8.88	5.82
F-probability	<0.01	<0.01	<0.01	<0.01	<0.01
Grand mean	1.74	15.28	33.23	7.76	0.41

3.5 Benefit Cost Ratio

Highest cost of cultivation was obtained with the recommended. $NP_2O_5K_2O$ +Zn +B(Rs.1,17,557) followed by recommended $NP_2O_5K_2O$ +B(Rs.1,14,837) and recommended $NP_2O_5K_2O$ + Zn (Rs.1,13,748) while lowest cost of cultivation was obtained with the Farmer practice (Rs.1,08,191) which was followed by recommended $NP_2O_5K_2O$ (Rs.1,11,028). Similarly, Highest net return was obtained with the recommended $NP_2O_5K_2O$ +Zn +B(Rs.1,07,693) followed by recommended. $NP_2O_5K_2O$+Zn (Rs.91,252) and recommended $NP_2O_5K_2O$ +B(Rs.84,913) while lowest net return was obtained with the farmer practice (Rs.54,809) which was followed by recommended. $NP_2O_5K_2O$ (66,722). Similarly, highest benefit cost ratio(B:C) was obtained with the recommended $NP_2O_5K_2O$ +Zn+ B (1.92) followed by recommended $NP_2O_5K_2O$+Zn (1.80) and recommended $NP_2O_5K_2O$ Rec. NPK+B (1.74) while lowest B:C ratio was obtained with the farmer practice which was followed by recommended $NP_2O_5K_2O$ Rec. NPK (1.60). Cost of cultivation included all the fix and variable expenses like cost of land on lease, land preparation, labor cost, fertilizer, insecticide while gross return was calculated based on local prize of maize grain and maize straw. Nearly, double return was obtained

The combine application of recommended $NP_2O_5K_2O$ (150:60:40kg ha^{-1}), Zn(15kg ha^{-1}) and B(2kg ha^{-1}) increased the yield attributing traits namely cob length, and thousand-grain weight, grain yield, net return and there by grain yield in Kanchan hybrid maize (*Zea mays L.)* which increase the net return and B:C ratio. Therefore, the use of recommended. $NP_2O_5K_2O$(150:60:40kg ha^{-1}) +Zn(15kg ha^{-1}) +B(2kg ha^{-1}) is beneficial to get the higher maize production in Pyuthan district in spring season. Fertilization at the right rate, right time and right method could decrease the N losses through leaching and volatilization and increase the recovery of applied N and hence increase the yield. Soil analysis should be done to determine the level of fertilizer doses. The dose of essential micro-nutrition like zinc and boron should be assessed base on agro-ecological zone and recommended to the farmers for reducing the yield gap. The farmer should be made aware on the nutrition management. With the recommended $NP_2O_5K_2O$ +Zn compared to farmer practice. The above results are in line with who observed that the application of Zn and B has increase the yield by 15% in Zimbabwe,>10% in Switzerland, by 9% in China respectively which cause increase in benefit cost ratio (Shorrocks and Blaza 1973; Mozafar 1987; Li and Liang 1997). A group researchers reported soil application of Zn and B in combination performed better and fetched high returns from maize crop (Kumar et al., 2019).

Table 5: B:C ratio of hybrid maize production as influenced by the application of different nutrient

Treatment	BC ratio			
	cost of Cultivation (Rs/ha)	Gross Return (Rs/ha)	Net Return (Rs/ha)	B:C Ratio
Farmer practice	1,08,191	1,63,000	54,809	1.51
Recommended NPK	1,11,028	1,77,750	66,722	1.60
Rec. NPK + Zinc	1,13,748	2,05,000	91,252	1.80
Rec. NPK + Boron	1,14,837	1,99,750	84,913	1.74
Rec. NPK +Zinc + Boron	1,17,557	2,25,250	1,07,693	1.92

3.6 Co-Relation Coefficient

The correlation between grain yield and number of grains per row was found significant ($p<0.001$) positively ($r = 0.894922$). The coefficient of determination $R^2=0.7818$ that means there is 78.18% effect of number of grains per row on grain yield and rest was due to other factors.

The correlation between grain yield and 1000 grain weight was found significant ($p<0.001$) positively ($r = 0.86$). The coefficient of determination $R^2=0.7337$ that means there is 73.37% effect of 1000 grain weight on grain yield and rest was due to other factors.

The correlation between grain yield and number of rows was found significantly ($p<0.001$) positively ($r = 0.368$) The coefficient of determination $R^2=0.1357$ that means there is 13.57% effect of number of rows on grain yield and rest was due to other factors. The correlation between grain yield and sterility percentage was found significantly ($p<0.001$) positively ($r = 0.599$) The coefficient of determination $R^2=0.3592$ that means there is 35.92% effect of sterility % on grain yield and rest was due to other factors.

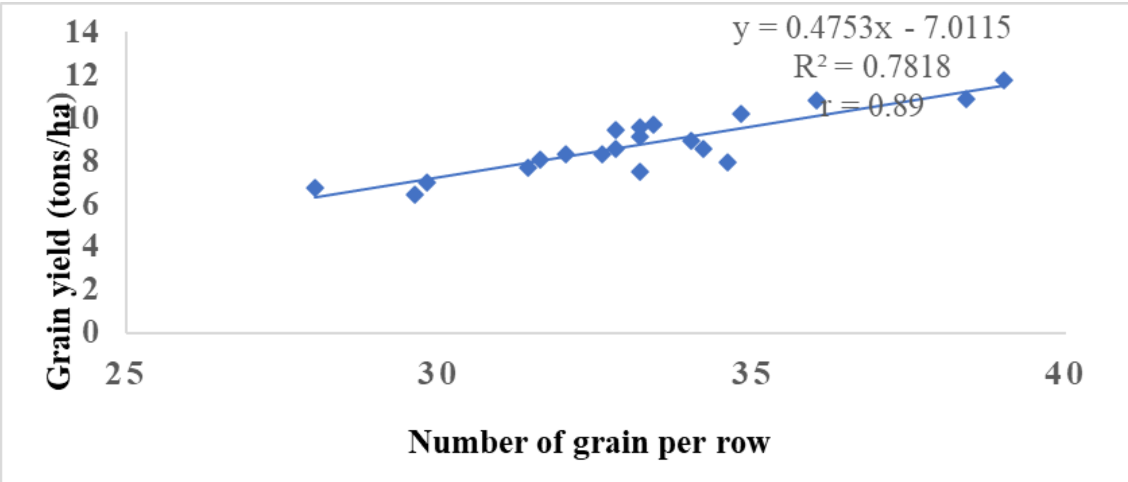

Figure 5: Correlation between grain yield and number of grains per row

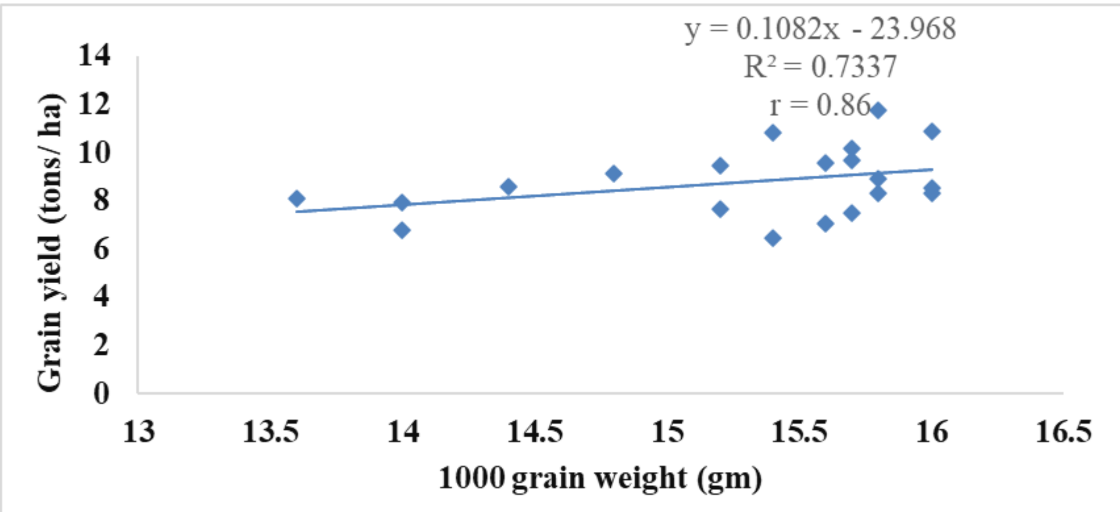

Figure 6: Correlation between grain yield(tons/ha) and 1000 grain weight(gm)

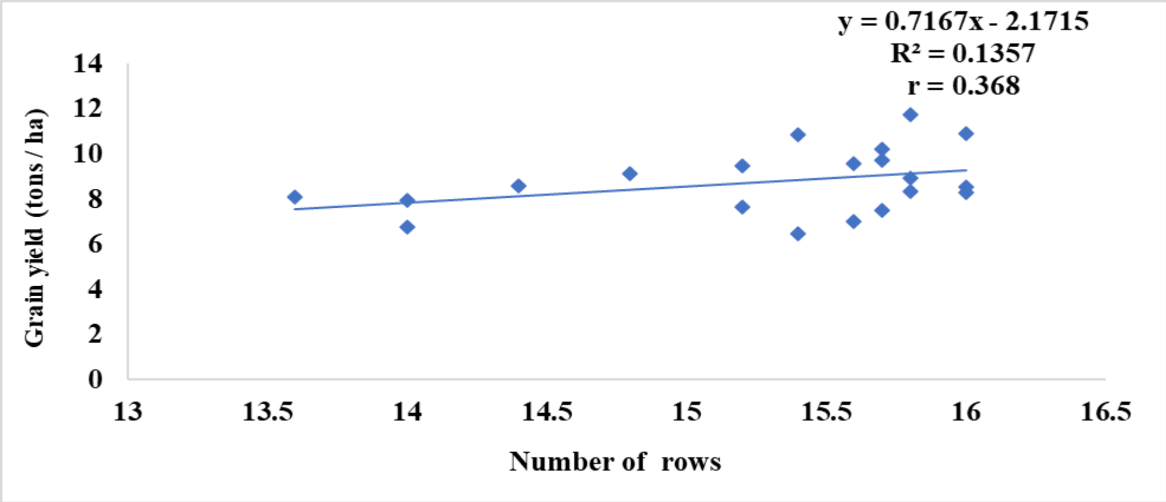

Figure 7: Correlation between grain yield (t-ha^{-1}) and number of rows

4. Conclusions

The combine application of recommended $NP_2O_5K_2O$. 150:60:40 kg ha^{-1}, Zn15 kg ha^{-1} and B 2 kg ha^{-1} increased the yield attributing traits namely cob length, and thousand-grain weight, grain yield, net return and there by grain yield in Kanchan hybrid maize (*Zea mays L.)* which increase the net return and B:C ratio. Therefore, the use of recommended. $NP_2O_5K_2O$ 150:60:40kg ha^{-1} +Zn 15 kg ha^{-1} +B 2 kg ha^{-1} is beneficial to get the higher maize production in Pyuthan district in spring season. Fertilization at the right rate, right time and right method could decrease the N losses through leaching and volatilization and increase the recovery of applied N and hence increase the yield. Soil analysis should be done to determine the level of fertilizer doses. The dose of essential micro-nutrition like zinc and boron should be assessed base on agro-ecological zone and recommended to the farmers for reducing the yield gap. The farmer should be made aware on the nutrition management.

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