VIGOR AND VIABILITY OF MAIZE SEEDS AS AFFECTED BY NITROGEN AND POTASSIUM LEVELS

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Abstract: Nitrogen is so vital because it is a major component of chlorophyll, the compound by which plants use sunlight energy to produce sugars from water and carbon dioxide (i.e. photosynthesis). It is also a major component of amino acids, the building blocks of proteins and potassium is associated with the movement of water, nutrients and carbohydrates in plant tissue. It's involved with enzyme activation within the plant, which affects protein, starch and adenosine triphosphate (ATP) production. The production of ATP can regulate the rate of photosynthesis. The research was conducted to know the effect of nitrogen and potassium levels on the vigor and viability of maize seeds at Agronomy Research Laboratory, The University of Agriculture Peshawar during 2021-2022. The experiment was laid out in randomized complete block design (RCBD) having three replications. The experiment is consisted of two-factors in which one factor was nitrogen levels (0, 60, 120 and 180 kg ha^{-1}) and the other was potassium levels (0, 30, 60 and 90 kg ha^{-1}). Based on experimental results nitrogen applied at the rate of 180 kg ha^{-1} increased germination (90.0 %), germination rate (9.0), plumule length (10.2 cm), root length (12.4 cm), seedling fresh weight (0.32 g), seedling dry weight (0.01 g), electrical conductivity(179.5 µS/cm) and vigor (1568.7). The application of potassium at the rate of 90 kg ha^{-1} showed positive response in all the parameters and increased germination (90.0 %), germination rate (9.0), plumule length (8.7 cm), root length (10.6 cm), seedling fresh weight (0.33 g), seedling dry weight (0.01 g), electrical conductivity(182.0 µS/cm) and vigor (1499.2). Interaction between nitrogen and potassium levels was found significant for seedling fresh weight and electrical conductivity. From the results it was concluded that nitrogen application at rate of 180 kg ha^{-1} and potassium at rate of 90 kg ha^{-1} is recommended for increasing vigor and viability of harvested maize seeds.

Keywords: Vigor, Viability, Maize, Nitrogen, Potassium

I. INTRODUCTION

Maize (*Zea mays* L.) a member of grass family (Gramineae) originated in Central America, is used by human civilization even in the ancient times. Having high genetic potency and is a photosynthesis explorative crop. Maize grain contains about 79% starch, 10% protein, 4% fiber, 4%fat and 3% minerals (Ahmad et al., 2017). It is mostly grown for grain as well as for fodder purposes and is also used as a raw material by various manufacturing units like cooking oil, confectionary and backers. The global maize production is approximately 1,060.2 million tonnes on an area of 188 million hectares with an average yield of 5.63 tonnes per hectare (USDA, 2016-17). Among the 176 countries worldwide, United States is ranked first with the production of 370.96 million tonnes on an area of 33.4 million hectares. China, Brazil, European Union and Argentina are the other top ranked maize producing countries. Pakistan comes at 17th place in the ranking. In Pakistan, maize was cultivated on an area of 1.3 million hectares in 2014-15 with a total production of about 6 million tonnes and an average yield of 4.32 tonnes ha^{-1}. Therefore, maize should get priority considering the protein malnourishment of the people, because it encompasses more digestible protein than the other cereals (Ahamed et al. 2010). Poor nutritional balance (lowering N, P, K^+, Ca^{2+} unbalanced carbon metabolism) (Abdelhamid et al. 2013) and stunted stem length, stem width, leaf blade thickness, leaf vascular bundle length and leaf xylem vessels (Dawood et al. 2014; Semida et al. 2014). Reduction of nutrient uptake capacity often accompanied by mineral toxicity leading to nutritional imbalance (Schmidhalter et al. 2005).

Nitrogen fertilization increased number of leaves per plant and leaf area (Noeman et al. 1990; Gasim et al. 2001). John and (Warren et al. 1967) noted that the addition of nitrogen increased stem diameter. (Koul et al.1997) recorded that nitrogen application resulted in greater values of plant height, leaf area, number of leaves and stem diameter of fodder maize, fresh and dry forage yield were also increased due to addition of nitrogen. Leaf to stem ratio was found also to be increased by nitrogen (Duncan et al. 1980). These findings are in full agreement with that of (Gasim et al. 2001) who reported that the increase in leaf to stem ratio with nitrogen application is probably due to the increase in number of leaves and leaf area under nitrogen treatments, producing more and heavy leaves. The uptake of nitrogen by maize is low during early development and increased at tasseling. Although only relatively small amounts of fertilizers are required during the very early stages of plant growth, high concentration of nutrients in the roots zone at that time are beneficial in promoting early growth (Ritchie et al., 1993). Has observed that nitrogen fertilization accelerated the time to reach 50% tasseling, promoted the fresh and dry forage weight. (Salem et al. 1979) found that nitrogen application increased the number of ears per plant, ear height, number of days to mid-silking and protein content, and decreased the number of barren stalks. Grain protein content was increased by nitrogen (Gangwar et al. 1988).

Potassium (K) as one of essential macronutrients has various functions on crop development, growth and yield formation process, serving as a cofactor for more than 40 enzymes in different metabolic pathways, regulation of cell osmotic pressure and stomatal movements (Clarkson et al. 1980; Marschner et al. 2011). Soil nutrient deficiency has directly endangered the world food security in developing and underdeveloped countries (Tan et al. 2005; Anderson et al. 2014). Large farmlands of the world were reported to be deficient in K including India, China, Southern Australia, etc. (Rengel et al. 2008; Jin et al. 2012). In addition, lower fertilizer K application in many cases of unbalanced fertilization has led to declined soil fertility (Vitousek et al. 2009; Zörb et al. 2014). The ability of plant absorbing nutrients and water from soil is related to its capacity developing an abundant root system, working as intermediary between plant and soil. Plant root system can not only regulate morphology and architecture to adapt to soil condition, but they significantly adjust the metabolism to more effectively acquire the nutri- ents (Zhang et al. 2010). Localized application of appropriate nitrogen (N) plus phosphorus (P) fertilization can significantly improve maize root growth and nutrient uptake at seedling stage by intensifying root proliferation and rhizosphere acidification on calcareous soil (Jing et al. 2012). However, excessive application of N fertilizer may also inhibit root morphological development during intensive maize production (Tian et al. 2008). Conversely, nutrient starvation can affect shoot and root growth. Under K or Mg deficiency, sucrose export in phloem exudate was remark- ably decreased in leaves and much lower proportions of photosynthates were distributed to the roots, thus changing metabolite concentrations in bean plant organs (Cakmak et al. 1994a, b). Comprehending the adaptations of root systems to nutrient deficiency has been pointed out as the key issue in modern agriculture (Herder et al. 2010). Plant root development is adjusted by the integration of endogenous factors, such as phytohormones, with integrate environmental stimuli, such as soil nutrients (Osmont et al. 2007; Petricka et al. 2012). Particularly, phytohormones play an important role on plant development and acclimating response to abiotic stress (Francozorrilla et al. 2004). Some reports have indicated that P starvation leads to a variation in ethylene and auxin responsiveness in the root (Borch et al. 1999; Lópezbucio et al. 2002). In addition, auxin (IAA), cytokinin (CK), abscisic acid (ABA), and ethylene have been considered to play a role in plant response to K deficiency in Arabidopsis (Jung et al. 2009). Reported that WOX11 gene-controlled root and shoot phenotypes in the OsHAK 16p: WOX 11 transgenic lines by improving ex- pression of several RR genes encoding type-A cytokinin-responsive regulators, PIN genes encoding auxin transporters and Aux/IAA genes in rice root under K-deficiency condition. Moreover, the increased ethylene crosstalks with ABA, IAA and CK to adapt flooding stress condition, especially aer- enchyma cells were improved by those kinds of interactions under waterlogging stress (Shimamura et al. 2014; Kim et al. 2015). However, roles of phytohormone in K deficiency are still unclear in maize at present time.

Keeping the above points in view, an experiment was conducted to check the effect of different nitrogen and potassium Levels on vigor and viability of maize seed.

MATERIALS AND METHODS

The experiment was carried out in Agronomy Research Laboratory, The University of Agriculture Peshawar April - May 2021. The experiment was designed in a randomized complete block design having three replications. Materials that used in this research were three replications of maize seed grown under two-factors in which one factor was nitrogen levels (0, 60, 120 and 180 kg ha^{-1}) and the other was potassium levels (0, 30, 60 and 90 kg ha^{-1}). 50 seeds of each replication were tested.

The following factors were studied in the experiments:

Factor A: Nitrogen levels (kg ha^{-1})

N_0	=	0
N_1	=	60
N_2	=	120
N_3	=	180

Factor B: Potassium levels (kg ha^{-1})

P_0	=	0
P_1	=	30
P_2	=	60
P_3	=	90

Data was recorded based on the following parameters:

1. Germination percentage (%)
2. Germination rate
3. Plumule length (cm)
4. Root length (cm)
5. Seedling fresh weight (g)
6. Seedling dry weight (g)
7. Electrical conductivity (µS/cm)
8. Vigor index

The following laboratory experiment was conducted.

Laboratory Experiment

Standard germination test

Standard germination test was conducted for seeds as described in (ISTA, 1999). Three replicates × 50 seed of each replication were tested. Wet filter paper was used as germination medium for maize seeds in incubator. The Number of normal seedlings was observed after a 10-day. The temperature of incubator was set on 25°C. To calculate germination percentage the formula is, divide the number of healthy seedlings by the total number of seeds in the test and multiply by 100.

Germination % = (Total sprouted seedlings/ Total seeds) x 100.

Germination rate

The total number of seeds germinated as per total number of days for germination.

Germination rate = (Total number of seeds sprouted / Total days for germination).

Plumule length (cm)

The selected the seedling was cut into two parts. Then plumule length was measured with ruler foot.

Root length (cm)

The selected the seedling was cut into two parts. Then root length was measured with ruler foot.

Seedling fresh weight (g)

After incubated for 10-day seedlings of five plants from each treatment were selected to weigh the seedling fresh weight.

Seedling dry weight (g)

Separated plant parts were dried at 25ºC for 48 hours, the dry weight of plant part was determined.
Total Seedling dry weight is determined as;
Total Seedling dry weight= plumule dry weight + root dry weight.

Electrical conductivity (µS/cm)

Three replicates of 50 seeds are weighed and then placed in a measured amount of deionized water. The seeds are soaked for 24 hours at 20ºC. The leachate of the water is measured by an electrical conductivity meter.

Vigor index

The vigor index of the seedlings can be estimated as: VI=RL+SL×GP, where RL is root length (cm), SL is shoot length (cm) and GP is germination percentage.

Statistical analysis

Data were analyzed statistically according to the procedure relevant to randomized complete block design design in MS Excel. Least significance difference test was used (Jan et al., 2009).

I. RESULTS

Germination percentage (%)

Data regarding germination percentage of maize is given in Table 01. Statistical analysis revealed that germination percentage was significantly affected by nitrogen and potassium levels. Nitrogen at the rate of 180 kg ha^{-1} have higher germination percentage (90 %) which were followed by 120 kg ha^{-1} (84.16 %) and 60 kgha^{-1} (81.66 %) while lower was recorded at control treatments. The potassium 90 kg ha^{-1} have higher germination percentage (90 %) followed by 60 kg ha^{-1} (84.19 %) and 30 kg ha^{-1} (80.83 %). The 180 kg ha^{-1} nitrogen and potassium 90 kg ha^{-1} have more germination percentage (96.66 %).

Germination rate

Data regarding germination rate is given in Table 01. Statistical analysis revealed that germination rate was significantly affected by nitrogen and potassium levels. Nitrogen at the rate of 180 kg ha^{-1} have higher germination rate (9.0) which were followed by 120 kg ha^{-1} (8.4) and 60 kgha^{-1} (8.1) while lower germination rate at control treatments. The potassium 90 kg ha^{-1} have higher germination rate (9.0) followed by 60 kg ha^{-1} (8.4) and 30 kg ha^{-1} (8.0). The 180 kg ha^{-1} nitrogen and potassium 90 kg ha^{-1} have more germination rate (9.6).

Plumule length (cm)

Data regarding plumule length is given in Table 01. Statistical analysis revealed that plumule length was significantly affected by nitrogen levels. Nitrogen at the rate of 180 kg ha^{-1} have maximum plumule length (10.2 cm) which were followed by 120 kg ha^{-1} (7.2 cm) and 60 kgha^{-1} (6.8 cm) while minimum plumule length was obtained at control treatments. The potassium 90 kg ha^{-1} have maximum plumule length (8.7 cm) followed by 60 kg ha^{-1} (8.5 cm) and 30 kg ha^{-1} (7.6 cm). The nitrogen 180 kg ha^{-1} and potassium 90 kg ha^{-1} showed maximum plumule length (15.7 cm).

Root length (cm)

Data regarding root length are given is Table 01. Statistical analysis revealed that root length was significantly affected by nitrogen and potassium levels. Nitrogen at the rate of 180 kg ha^{-1} has increased root length (12.4 cm) which were followed by 120 kg ha^{-1} (8.4 cm) and 60 kg ha^{-1} (7.8 cm) while root length was decreased at control treatments. The potassium 90 kg ha^{-1} have more root length (10.6 cm) followed by 60 kg ha^{-1} (9.5 cm) and 30 kg ha^{-1} (8.6 cm). Nitrogen 180 kg ha^{-1} and potassium 90 kg ha^{-1} showed maximum root length (12.8 cm).

Table 01. Effect of nitrogen and potassium levels on germination (%), germination rate, plumule length (g) and root length (g) of maize seeds.

Treatments					
Nitrogen (Kg ha-1)		Germination %	Germination rate	Plumule length (cm)	Root length (cm)
N_0	0	79.16 b	7 b	6.4 b	6.5 b
N_1	60	81.66 b	8 b	6.8 b	7.8 b
N_2	120	84.16 ab	8 a b	7.2 b	8.4 b
N_3	180	90.0 a	9.0 a	10.2 a	12.4 a
Phosphorous (Kg ha-1)					
P_0	0	80.0 b	8.0 b	5.8 b	6.5 b
P_1	30	80.83 b	8.0 b	7.6 a b	8.6 a b
P_2	60	84.16 a b	8.4 a b	8.5 a	9.5 a
P_3	90	90.0 a	9.0 a	8.7 a	10.6 a
LSD 0.05 value		8.3	0.83	2.6	2.3

Means of the same category followed by same lettering are significantly different.

Seedling fresh weight (g)

Data regarding seedling fresh weight is given in Table 02. Statistical analysis revealed that seedling fresh weight was significantly affected by nitrogen and potassium levels. Nitrogen at the rate of 180 kg ha^{-1} has higher seedling fresh weight (0.32 g) which was followed by 120 kg ha^{-1} (0.15 g) and 60 kgha^{-1} (0.14 g) as compared to control treatments. The potassium 90 kg ha^{-1} have more seedling fresh weight (0.33 g) followed by 60 kg ha^{-1} (0.15 g) and 30 kg ha^{-1} (0.14 g) than control treatments. Nitrogen 180 kg ha^{-1} and potassium 90 kg ha^{-1} showed maximum seedling fresh weight (0.33 g).

Seedling dry weight (g)

Data regarding seedling fresh weight is given in Table 02. Statistical analysis revealed that seedling dry weight was significantly affected by nitrogen and potassium levels. Nitrogen 180 kg ha^{-1} have more seedling dry weight (0.016 g) then nitrogen applied plots which were followed by 120 kg ha^{-1} (0.014 g) while lower seedling fresh weight (0.01 g) was recorded at control. The potassium 90 kg ha^{-1} have more seedling dry weight (0.018 g) followed by 60 kg ha^{-1} (0.013 g) and 30 kg ha^{-1} (0.01 g) while lower was recorded at control. Nitrogen 180 kg ha^{-1} and potassium 90 kg ha^{-1} showed maximum seedling dry weight (0.016 g).

Electrical conductivity (µS/cm)

Data regarding electrical conductivity is given in Table 02. Statistical analysis revealed that electrical conductivity was significantly affected by nitrogen and potassium levels. However, nitrogen 180 kg ha^{-1} have more electrical conductivity (179.5 µS/cm) then nitrogen applied plots which were followed by 120 kg ha^{-1} (174.1µS/cm) and 60 kgha^{-1} (165.3 µS/cm). The potassium 90 kg ha^{-1} have more electrical conductivity (182 µS/cm) followed by 60 kg ha^{-1} (171.2 µS/cm) and 30 kg ha^{-1} (165.2 µS/cm). Nitrogen 180 kg ha^{-1} and potassium 90 kg ha^{-1} showed maximum electrical conductivity (200.3 µS/cm).

Vigor index

Data regarding vigor index is given in Table 02. Statistical analysis revealed that vigor index was significantly affected by nitrogen however insignificant results were obtained at potassium levels. Nitrogen 180 kg ha^{-1} has more vigor index (1568.7) then nitrogen applied plots which were followed by 120 kg ha^{-1} (1414.8) and 60 kgha^{-1} (1381.2). The potassium 90 kg ha^{-1} have more vigor index (1499.2) followed by 60 kg ha^{-1} (1403.3) and 30 kg ha^{-1} (1397.8). Nitrogen 180 kg ha^{-1} and potassium 90 kg ha^{-1} showed maximum vigor index (1528.0).

Table 02. Effect of nitrogen and potassium levels on germination (%), germination rate, plumule length (g) and root length (g) **of** maize seeds.

Treatments					
Nitrogen (Kg ha-1)		**Seedling fresh weight (g)**	**Seedling dry weight (g)**	**Electrical conductivity (µS/cm)**	**Vigor index**
N_0	**0**	0.13 d	0.01 c	156.4 d	1213.8 b
N_1	**60**	0.14 c	0.011 c	165.3 c	1381.2 ab
N_2	**120**	0.15 b	0.014 b	174.1 b	1414.8 ab
N_3	**180**	0.32 a	0.016 a	179.5 a	1568.7 a
Phosphorous (Kg ha^{-1})					
P_0	**0**	0.12 d	0.01 b	156.9 d	1288.3 a
P_1	**30**	0.14c	0.011 b c	165.2 c	1387.8 a
P_2	**60**	0.15 b	0.013 b	171.2 b	1403.3 a
P_3	**90**	0.33 a	0.018 a	182.0 a	1499.2 a
LSD 0.05 value		8.3	7.3	2.4	4.1

Means of the same category followed by same lettering are significantly different.

DISCUSSION

Nitrogen and potassium had significant effect on seedling fresh weight of maize seeds. At rate of 180 kg ha^{-1} nitrogen showed maximum seedling fresh weight. The results was supported by Jat et al. (2013) that the fertilizers, nitrogen (N) is very important because this element is responsible on major activities for growth and development of maize crop. Lee et al. (2012). Nitrate (NO_3^-) and ammonium (NH_4^+) are two main kinds of inorganic N forms required for plant growth and their relative contribution depends on the species, environmental condition, developmental stage and total N concentration.

Nitrogen and potassium had significant effect on electrical conductivity of maize seeds. The 180 kg ha^{-1} of nitrogen showed maximum electrical conductivity. The results was supported by Yanai et al. (1995). showed that cation and anion concentrations were related as the soil solution composition changed during plant growth, and the dynamics was mostly influenced by the change of NO_3^- concentration. N application was expected, therefore, to have complex effects on the dynamics of the soil solution composition during plant growth. Chen et al. (2021). Nitrogen fertilizer were added to black soil under a maize monocropping system in northeast china. At the end of the 5-year field trial, the abundance and community structure of diazotrophs in the bulk soil and rhizosphere were investigated at the maize jointing stage by real-time quantitative polymerase chain reaction (qRT-PCR) and high-throughput sequencing. The results showed that nitrogen increased electrical conductivity.

Nitrogen and potassium had significant effect on seedling dry weight of maize seeds. The 180 kg ha^{-1} of nitrogen showed maximum seedling dry weight. The results was supported by Aslam et al. (2011). Increase in nitrogen dose increased the fresh weight of plant. Both dry weight and fodder yield increased with increase in seed rate and nitrogen levels. Safdar et al. (1997) had also reported an increase in ash contents with increase in nitrogen rate in maize fodder. Abdel et al. (2013). The dry weight was correlated with grain yield under high nitrogen.

Nitrogen and potassium had significant effect on root length of maize seeds. The 180 kg ha^{-1} of nitrogen showed maximum root length. The results was supported by Anderson et al. (1998). Increased root growth in the surface soil layers due to tillage and N fertilization. Total root length increased with nitrogen fertilization. Mackay et al. (1986). Root length and root surface area were increased by the application of nitrogen in contrast applied nitrogen increased root growth.

V. LITERATURE CITED

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