Research Article

Response of maize to nitrogen levels and seed priming

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Abstract

A field experiment was conducted to measure the impact of seed priming and nitrogen levels on maize yield and nitrogen uptake. Research was carried out in randomized complete block design with three replications at The University of Agriculture, Peshawar, Pakistan. Nitrogen at the rate of 0, 75 and 150 kg ha⁻¹ were applied at three split doses, such as at sowing, knee and tasseling stage along with dry seed, water soaked and seed primed with potassium di-hydrogen phosphate (KH₂PO₄) at the rate of 0.2 % Phosphorous concentration. Seeds were soaked for 12 hours and then air dried for 30 minutes. Maize biological yield, grain yield, Stover yield, grains per cob, thousand grain weights, harvest index and total N uptake were significantly (P≤0.05) affected by seed priming and nitrogen levels. Maximum values of mentioned parameter were recorded at 150 kg N ha⁻¹ in seeds primed with 0.2% phosphorous solution. Minimum values of all parameters were noted for control. P priming enhanced total N uptake by 34% than the dry seed. . Thus it is concluded that use of nitrogen at 150 kg ha⁻¹ along with 0.2% P priming gives maximum maize yield and high N uptake.

Key words: Phosphorous; Biological yield; AB-DTPA; RCB (randomized complete block); DM

Introduction

Maize (*Zea mays* L.) is a cereal exhaustive crop used for many purpose such as a food for humans, feed for livestock and raw material for industries [1]. On the basis of area and production within the cereals maize occupied 3rd position after the wheat and rice in Pakistan, while it come on 2nd after wheat in Khyber Pakhtunkhwa. During the year 2012-2013 it was cultivated on 1,060 thousand hectares area with total production

was 4,220 thousand tons in Pakistan and in same year it was cultivated on 440.60 thousand hectares area and there total production was 833.56 thousand tons in KPK [2].

To increase the yield of cereal crops nitrogen play a very imperative role because it promotes strong vegetative growth and produced deep green colour [3]. Nitrogen have many function in plant body like it is a major constituent of amino acids, building blocks of

proteins and also part of DNA, RNA and nucleic acid [4]. According to an estimate 1 to 4% of the plant dry matter is consist of nitrogen, which is an essential macro nutrient [2]. Sufficient availability of nitrogen throughout the growing season is essential for plant growth processes such as production of chlorophyll and many enzymes and also mediates the utilization of potassium, phosphorus and many other elements in plants [5]. Nitrogen plays a vital role in physiological status of plant.

Nitrogen deficiency or excess can reduced the yield of maize and utilization of other plant nutrients. Nitrogen fertilizers requirement for maize varies with cultivars and environmental condition but however, maize nitrogen requirement as high as 150-200 kg N ha⁻¹ [6]. According to an estimate the application of nitrogen fertilizer will increase maize yield by 60-70 percent in year 2025 and two-third of this will be applied in developing world [7].

Seed soaking is recommended to enhance the production in many parts of the world. The primed seed have used by the farmer in past to fill gapes [8]. Seed priming is the soaking of seed then drying back to storage moisture [9]. Seed priming is simple, economical process safe and sound to the environment [10]. Several researcher established that seed soaking have a lot of advantages such as early and rapid emergence, higher water use efficiency, deeper roots, uniformity in emergence, increasing in root growth, break of seed dormancy, germination in wide range of temperature, reproductive organ initiation, early flowering and maturity, resistance to environmental stresses (drought and salinity) and diseases (*Sclerotium rolfsii* L.): Higher grain yield in wheat (*Triticum aestivum* L.) [11] and maize (*Zea mays* L.) [12]. Seed of wheat primed with P increase emergence m⁻², tiller m⁻², grains spike⁻¹, thousand grain

weight and grain yield as compared to non-primed seed [1]. It is confirmed that seed soaking with a 1% phosphorous solution using KH₂PO₄ enhanced fertilizer use efficiency and increased yield and profit for different crops which is grown on phosphorous deficient soil [13]. Therefore the present experiment was designed to evaluate the effect of nitrogen levels and seed priming on yield and yield component of maize and their uptake of N under the semi-arid of climatic condition.

Materials and methods

Experimental Site

The experiment was conducted at the New Developmental Farm (NDF) Khyber Pakhtunkhwa, the University of Agriculture, Peshawar, Pakistan during 2013. Peshawar under Koppen's climate classification features has a semi-arid climate with very hot summers and mild winters. It is located at 34°01'N and 71°35'E. The Physico-chemical characteristics of the experimental site are given in Table 1.

Experimental design and treatments:

Two factorial RCB design with three replications was used and plot size was kept 4.5m x 4m. The experiment was consisted of two factors including three nitrogen levels (0, 75, 150 kg ha⁻¹) applied at three split doses such as (sowing, knee stage, tasseling stage) and three seed priming such as (dry, water soaked and 0.2% P soaked seed using KH₂PO₄). Seed per plot was sealed in perforated plastic bags and the bags were soaked in distilled water and aqueous solution of P for 12 hours. After soaking, bags were removed, drained and then surface dried in shade for around half an hour to facilitate clump-free sowing using maize variety Azam with seed rate of 40 kg ha⁻¹. Urea was used as sources of nitrogen and SSP was used as sources of P. Phosphorous were used at the rate of 100 kg ha⁻¹ at sowing time.

Table 1. Physio- chemical characteristics of the soil under study

Property	Units	Concentration
Sand	%	41.4
Silt	%	51.4
Clay	%	7.2
Textural class	-	Silt loam
pH (1:5)	-	7.61
Electrical conductivity(EC)	d Sm ⁻¹	1.12
Lime	%	15.3
Organic matter content	%	0.9
Total nitrogen content	%	0.1
Bulk density	gm cm ⁻³	1.35
AB-DTPA extractable P	mg kg ⁻¹	2.14

Statistical analysis

Analysis of variance procedure was followed for the statistical analysis of recorded data according to the design used. Means was compared using least significant differences test at $P \leq 0.05$ upon significant F-test [14].

Results and discussion

Biological yield (kg ha⁻¹)

Biological yield represent total amount of above ground biomass accumulated by the plant. Data regarding the biological yield of maize are given in (Table 2). Analysis of the data showed that nitrogen levels and seed priming significantly ($P \leq 0.05$) affected biological yield of maize. Biological yield increase (4788 kg ha⁻¹) with application of 150 kg N ha⁻¹ as compare to control (0 kg N ha⁻¹) similarly seed priming also improved biological yield. Biological yield was increased (1126 kg ha⁻¹) with P primed seed as compare to non-primed seed (control). The interaction between priming and nitrogen revealed that increased the levels of nitrogen the biological yield increased, all the three lines were linearly increased but the maximum biological yield showed by

priming line (0.2%P) (Fig. 1). These results are similar with the finding of [15] and [16] whose reported that the different levels of nitrogen increased significantly the biological yield of maize. [17] and [18] reported that primed seed significantly increased the total biomass

And dry weight as compared to control.

Grain yield (kg ha⁻¹)

Grain yield is significantly increased with nitrogen levels and seed priming. grain yield was increased (1864 kg ha⁻¹) with application of 150 kg N ha⁻¹ as compared to control with 0 kg N ha⁻¹ similarly Seed priming enhanced the grain yield. The seed which was soaked with P solution increased grain yield (576 kg ha⁻¹) as compare to non-primed seed. The interaction of nitrogen and priming significantly affect the grain yield. According to (Figure. 2) increase in the nitrogen levels linearly increased the grain yield and the maximum grain yield was showed by seed priming (0.2%P). Similar result was also reported by [19] and [20] respectively. Seed priming with water is also effective for increasing the maize yield [21].

Figure1. Biological yield of maize as influenced by interaction of nitrogen levels and seed priming

Figure 2. Grain yield of Maize as influenced by interaction of nitrogen levels and seed priming.

Stover yield (kg ha⁻¹)

Stover yield is given in Table 2 data showed that nitrogen levels and seed priming significantly ($P \leq 0.05$) increase the Stover yield of maize. But interaction was found non-significant. As increased the levels of nitrogen Stover yield was increased. The maximum yield was recorded at those plots which was treated with 150 kg N ha⁻¹ (6112 kg ha⁻¹) while minimum yield was obtained at 0 kg N ha⁻¹ (3188 kg ha⁻¹). According to the mean table maximum Stover yield was

recorded by P priming (4838 kg ha⁻¹) while the lower yield was noted in control plot (4288 kg ha⁻¹). These results are highly correlated with [22]. P primed and water soaked seed results are higher from control and these results are highly related with the results founded by [23] who reported that when seed primed with 0.2% P solution enhanced the straw yield also mentioned that seed priming increase 94% DM when primed with 1% P solution as compared to control

Table 2. Biological yield (kg ha⁻¹), Grain yield (kg ha⁻¹) and Stover yield of maize as influenced by seed priming and nitrogen levels

Nitrogen (kg ha ⁻¹)	Biological yield (kg ha ⁻¹)	Grain yield (kg ha ⁻¹)	Stover yield (kg ha ⁻¹)
0	4419c	1231c	3188c
75	6650b	2164b	4486b
150	9207a	3095a	6112a
L.S.D _{0.05}	119.2	29.5	96.6
Seed priming	-	-	-
No priming	6182c	1894c	4288c
Water priming	6786b	2126b	4660b
P priming	7308a	2470a	4838a
Interaction N × Priming	*Fig 1	*Fig 2	NS

Mean followed by different letters in each column are differ from each other significantly, NS=non-significant.

“*” = Significant at 0.05 percent

Grains cob⁻¹

The data grains per cob are shown in Table 3. Statistical analysis of data indicated that the levels of nitrogen and seed priming significantly ($P \leq 0.05$) effect grains cob⁻¹. The number of grains per cob was increased (67) at 150 kg N ha⁻¹ as compared to 0 kg N ha⁻¹ (control) similarly seed priming improved grains cob⁻¹ maximum grains cob⁻¹ was noted for P priming treatment and lower was on dry seed (control). Many researchers have founded increase in grains per pod in case of legumes or number of grains per cob in case of corn. Interactive effect of seed priming and nitrogen levels showed (Fig.3) results of water soaked and P priming were highly increased as compared to control but

the high yield of grains per cob was showed by high nitrogen levels with P priming (0.2%P). Our results are in line with the findings of [24] and [25] whose observed the similar increase or decrease effect on the parameter under discussion by the increase/decrease of dose of N. these results are in line with the data of [26] reported that increasing the levels of N increase the number of grains 28% and the increase is occurred due to the increasing of leaf area index. As results showed that priming seed have higher number of grains per cob then followed by water soaked seed while minimum grains cob⁻¹ obtained on dry seed. [23] had reported similar increase in number of grains cob⁻¹ having studied priming of

maize seed with phosphate solutions improves seedling growth and yield. Similarly [13] also noted similar increase in

number of grains spike⁻¹ of wheat primed with 0.3 % P.

Figure 3. Grains per cob in maize as affected by interactive effect of nitrogen levels and seed priming

Thousand grain weight (g)

Significant differences were observed among the nitrogen levels and seed priming (Table 3). Data indicated that thousands grain weight increased with increasing level of N. maximum thousand grain weight was obtained at 150 kg N ha⁻¹ (290g) followed by N level of 75kg ha⁻¹ (277 g) While minimum thousand grain weight was recorded at 0 kg N ha⁻¹ (252 g). Seed priming improved thousand grain weights. Higher thousand grain weight was recorded for P primed and water soaked seed (281 and 274 g, respectively). Lower thousand grain weight was recorded for dry seed (265 g). The result are in agreement with [27] who reported that the maize varieties have a different response to different levels of nitrogen, more leaf area exposed by the canopy has resulted higher grains and its weight and this results is supported by [28]. Similarly priming also improved thousand grains weight and the result is highly co-related with the results reported by [23] and [17].

Harvest index

Data regarding harvest index of maize (Table 3) showed significant differences for mean effect of nitrogen levels, seed priming and non-significant variation for the interaction of nitrogen levels and seed priming. Maximum harvest index (34%) was recorded in those plots which was applied 150 kg N ha⁻¹ followed (33%) for 75 kg N ha⁻¹ while the minimum harvest index (28%) was noted from those plots which have no nitrogen (control). Similarly higher harvest index (33%) was recorded from the P primed seed followed by water soaked seed (31%) and then dries seed (30 %). As harvest index was increased with increase in the rate of nitrogen, similar results were reported by [29], who stated that harvest index was significantly affected by nitrogen levels. As the seed priming effect on the harvest index was significant which was similar to the data recorded by [30] on effect of various priming sources on yield and yield components of maize cultivars and noted 60% of harvest

index when seeds were primed with Polyethylene glycol. The results were also supported by [31] who reported that harvest index increased with P priming.

Nitrogen uptake

The total nitrogen uptake data are reported (Table 3) that seed priming and levels of nitrogen increase significantly ($P \leq 0.05$) the total uptake of nitrogen in maize crop. Mean value of data showed that the maximum uptake of nitrogen was recorded on 150 kg N ha⁻¹ (201 kg N ha⁻¹) then followed by 75 kg N ha⁻¹ (129 kg N ha⁻¹) and lower uptake were noted on control plot (74 kg N ha⁻¹). similarly the seed which was treated with P (0.2%) have maximum uptake of nitrogen (155 kg N ha⁻¹) while minimum uptake was noted on

dry seed (112 kg N ha⁻¹). This may be due to increasing vegetative growth of crops which enhanced biological yield and enhanced total uptake by plant as compare to control which have no nitrogen. The interaction was also found significantly affected by nitrogen and priming. The total nitrogen uptake was high in P priming as increasing the levels of nitrogen (Fig.4). The results are highly correlated with the resulted observed by [32] similarly seed priming also enhanced uptake of nutrients and reported by [23] indicated that significant increase in P uptake due to the effect of seed priming in P solution. Similar results were also found by [33] who indicated that significant increase in Zn uptake by seedling due to nutrient priming.

Table 3. Grains cob⁻¹, thousand grains weight harvest index and total uptake of nitrogen of maize as influenced by seed priming and different nitrogen levels.

Nitrogen (kg ha ⁻¹)	Grains cob ⁻¹	1000 grain weight (g)	Harvest index (%)	Nitrogen uptake(%)
0	356c	252c	28c	74c
75	393b	277b	33b	129 b
150	423a	290a	34a	201a
L.S.D _{0.05}	2.02	2.1	0.306	0.306
Seed priming	-	-	-	-
No priming	371c	265c	30c	112c
Water priming	396b	274b	31b	138b
P priming	404a	281a	33a	155a
Interaction N × Priming	*Fig.3	NS	NS	* Fig.4

Mean followed by different letters in each column are differ from each other significantly NS=non-significant.

“*” = Significant at 0.05 percent

Figure 4. Interactive effect of nitrogen levels and seed priming on maize nitrogen

Conclusions and recommendations

Application of nitrogen at the rate of 150 kg ha⁻¹ improved yield and yield component as compared to other levels. Similarly, Phosphorous primed seed produced higher yield and yield component and N uptake as compared to water soaked and dry seed. Nitrogen application at the rate of 150 kg ha⁻¹ in split dose along with 0.2% of P solution seed priming could be recommended to the farmers for improved maize yield and N uptake.

Authors' contribution

Conceived the idea: M Ali, Collected data: Z Ullah, Statistical analysis: IA Mian, Performed statistical analysis: N Khan, N Khan, M Adan & M Saeed, Wrote the paper: Z Ullah.

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