 

# Influence of Hydrated Calcium Sulphate ($CaSO4.2H_2O$) and Nitrogen Levels on Water Infiltration Rate and Maize Varieties Productivity in Rainfed Area of Swat, Pakistan

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**Abstract**
An experiment was conducted at Departmental Maize SMP and Demonstration Plots in all Circles Of district Swat during summer 2014. To study the response of maize to hydrated calcium sulphate ($CaSO4.2H_2O$) and nitrogen levels and to enhance the water infiltration rate in rainfed areas of swat. Experiment was laid out in randomized complete block design (RCBD) with split plot arrangement. Data were recorded on days to tasseling, days to silking, ear length, grain ear$^{-1}$, thousand grains weight (g) and grain yield (kg ha$^{-1}$). Statistical analysis of the data showed that the effect of nitrogen and hydrated calcium sulphate ($CaSO4.2H_2O$) on grains ear$^{-1}$ was not significant. The effect of nitrogen and hydrated calcium sulphate ($CaSO4.2H_2O$) on days to tasseling, days to silking, ear length (cm), thousand grains weight (g) and grains yield (kg ha$^{-1}$) were significant. The effect of varieties was significant on all parameters. Higher grain yield (1819 kg ha$^{-1}$) and thousand grains weight (279 g) were recorded with the application of 120-40 kg NS ha$^{-1}$. Delayed days to tasseling (58.8) and silking (63.5) were observed at 200-0 kg NS ha$^{-1}$. Higher days to tasseling (57.6 days), silking (63.5 days), thousand grains weight (278 g) and grain yield (1730 kg ha$^{-1}$) were recorded in Pahari variety while Baber variety produced higher grains (422) ear$^{-1}$ and ear length(15.9 cm). 40-120 kg NS ha$^{-1}$ produced high yield.

## Introduction

Maize (*Zea mays* L) is a multipurpose crop that provides food for human, feed for animals especially poultry and livestock. It is a rich source of raw material for the industries where it is being extensively used for the preparation of cornstarch, corn, dextrose, corn syrup and corn flakes (Khaliq *et al*., 2004). It is the third most important summer cereal in Pakistan, after wheat and rice. In the farming system of Khyber Pakhtunkhwa maize is 2$^{nd}$ to wheat in its importance (Ihsan *et al*., 2005). The yield obtain from maize in Pakistan is very low as compared to other country due to many constraints. These include poor quality seed, indiscriminate application of fertilizers without soil test, poor tillage methods and lack of modern technology (Khattak *et al*., 2004). Among all the crop plants, maize is the most versatile one as it has great nutritive value 72% starch, 10% protein, 4.8% oil, 8.5% fiber, 3% sugar and 17% ash (Chaudhary, 1983).

Hydrated calcium sulphate is very essential for the synthesis of amino acids and activity of proteolytic enzymes. Hydrated calcium sulphate ($CaSO4.2H_2O$) fertilization improves both yield and quality of crops if adequate supply in the field is ensured (Hocking *et al*., 1987).The real importance of S has been marked in the recent past due to intensive cultivation with high yielding varieties and the use of complex fertilizers, which led to S deficiency in many farm soils (Islam *et al*., 1997). Hence the importance of S is being increasingly emphasized in the recent past because of its deficiency being widely reported in different parts of the country. Generally in the range of 12 to 20% yield increases in maize crop. Allen (1976), Grant and Kang and Osiname (1976). Hydrated calcium sulphate has specific functions during plant growth, metabolism, and enzymatic reactions (Mengal and Kirkby 1987). Hydrated calcium sulphate ($CaSO4.2H_2O$) is required for the synthesis of hydrated calcium sulphate-containing amino acids such as cystine, cysteine, and methonine. Hydrated calcium sulphate is also a constituent of S-glycosides (mustard oils), coenzymes-A, vitamin biotine, and thiamine (Tisdale *et al*. 1985). Maize yield increased up-to 43.4% when 22.4 kg S ha$^{-1}$ was applied Singh and Chhiba (1987). Maize yield increased by 20.5 with application of 72 kg S ha$^{-1}$. Haq et al. (1988) and Haq et al (1989). Maize crop showed increase in the yield 41% at 60 kg ha$^{-1}$ S application Baktash (2000). The average grain yield of maize is 0.99 t ha$^{-1}$ increased with application of hydrated calcium sulphate up to 40 kg ha$^{-1}$ Sekal et al (2000).

Organic manure can be supplemented with chemical fertilizers (Jama *et al*., 1997). Nitrogen is the key element in increasing grain yield and quality of maize. Nitrogen is the motor of plant growth and makes up to 1 to 4 percent of dry matter of the plants (Anonymous 2000). Nitrogen is a component of protein and nucleic acids and when N is sub optimal, growth is reduced (Haque *et al*. 2001). In recent years emphasis has been given to increase fertilizers use efficiency by top dressing and split applications of nitrogenous fertilizers at critical growth stages of maize (Singh, 1985). When too much nitrogen is applied, excess vegetative growth occurs, and the plant lodges with slightest wind. Crop maturity is delayed, and the plants are more susceptible to disease and insect pests (Muhammad, 2000). Nitrogen fertilization plays significant role in improving soil fertility and increasing crop productivity. N fertilization results in increased grain yield (43-68%) and biomass (25-42%) in maize (Ogola *et al*., 2002).Nitrogen fertilization increase corn yield when N supply by soil is low (Wienhold et al., 1995). Surface urea applications under no tillage system have a low efficiency, due to potential $NH_3$ volatilization losses during urea hydrolization (Keller and Mengel, 1986).

**Materials and Methods**

The experiment entitled "response of maize varieties to hydrated calcium sulphate and nitrogen levels" The experiment was conducted in randomized complete block design with split plot arrangement having three replications. Varieties (Baber and Pahari) were allotted to main plots, while nitrogen and hydrated calcium sulphate ($CaSO4.2H_2O$) application was allotted to subplot. Nitrogen was applied (0, 120 ,160 and 200) in the form of urea. Hydrated calcium sulphate ($CaSO4.2H_2O$) was applied (0, 20, 40 and 60 kg/ha). A sub plot size of 5 m x 3 m having 5 rows, 75cm apart and 4 m long was used. Agronomic practices were carried out uniformly.

**Statistical Analysis**

The data were statistically analyzed using analysis of variance appropriate for randomized complete block design. Combine analysis was performed to detect the variation between the years. Means were separated using LSD test at 0.05 level of probability (Steel and Torrie, 1984).

**Results and discussion**

**Days to tasseling**

Data on days to tasseling are depicted in Table 1. N x $CaSO_4$ combination and varieties has significantly affected days to tasseling, while interaction between of N x $CaSO_4$ combination and varieties were non significant. Comparing varieties Pahari delayed tasseling to (57.6 days) while early tasseling was observed in Baber (56.6 days). In case of NS combination 200-0 kg $ha^{-1}$ delayed tasseling (58.8 days) was recorded, where as early tasseling (54.7 days) was observed with the application of 120-40 kg NS $ha^{-1}$. Varieties and NS combination significantly effected days to tasseling. In case of varieties it might be due to the difference in genetic potential of these varieties. The probable reason may be that nitrogen enhances the vegetative growth due to which reproductive stage was delayed. The same pattern was observed by Rajput *et al.,* (1995) and Siandinis and Lazauskas (2005) who reported the days to tasseling delayed with increasing nitrogen. The interaction between varieties and NS combination had non significant effect on days to tasseling.

Table 1. Days to tasseling of maize as affected by nitrogen and hydrated calcium sulphate ($CaSO4.2H_2O$)

| NS (Kg $ha^{-1}$) | Varieties | | Mean |
|---|---|---|---|
| | Baber | Pahari | |
| 120-0 | 55.0 | 57.3 | 56.2abc |
| 160-0 | 58.7 | 58.7 | 58.7a |
| 200-0 | 58.3 | 59.3 | 58.8a |
| 120-20 | 56.3 | 56.3 | 56.3abc |
| 160-20 | 57.0 | 59.3 | 58.2ab |
| 200-20 | 56.0 | 59.7 | 57.8ab |
| 120-40 | 55.3 | 54.0 | 54.7c |
| 160-40 | 56.0 | 56.0 | 56.0abc |
| 200-40 | 56.0 | 55.3 | 55.7bc |
| Mean | 56.6b | 57.6a | |

**Days to silking**

Data pertaining days to silking are shown in Table 2. Analysis of the data indicated that days to silking were significantly affected by varieties and N x $CaSO_4$ combination, while interaction of N x $CaSO_4$ combination and varieties was non significant. Pahari variety delayed silking to 61.5 days while early tasseling (61 days) were observed in Baber. In case of NS combination delayed silking (63.5 days) was observed in the treatment of 200-0 kg NS $ha^{-1}$, while early silking (60.0 days) was observed in the treatment 160-40 kg NS $ha^{-1}$. Significant effect was observed by varieties on days to silking. It might be due to the difference in genetic potential of these varieties. NS combination also affected days to silking. With increasing nitrogen doses vegetative growth increases and delayed reproductive growth which is also reported by Park et al; (1987).

Table 2.Days to silking of maize as affected by nitrogen and hydrated calcium sulphate ($CaSO4.2H_2O$)

| NS (Kg ha$^{-1}$) | Varieties | | Mean |
|---|---|---|---|
| | Baber | Pahari | |
| 120-0 | 59.3 | 61.3 | 60.3bcd |
| 160-0 | 61.7 | 62.7 | 62.2abc |
| 200-0 | 64.0 | 63.0 | 63.5a |
| 120-20 | 60.3 | 60.3 | 60.3bcd |
| 160-20 | 61.3 | 63.3 | 62.3ab |
| 200-20 | 61.3 | 63.0 | 62.2abc |
| 120-40 | 59.7 | 58.7 | 59.2d |
| 160-40 | 60.0 | 60.0 | 60.0cd |
| 200-40 | 60.3 | 60.3 | 60.3bcd |
| Mean | 61.0b | 61.5a | |

**Ear length (cm)**

Data regarding ear length as affected by different combination of nitrogen and hydrated calcium sulphate $CaSO_4.2H_2O$ combination and varieties are depicted in Table 3. N x $CaSO_4$combination and varieties has significantly affected ear length, while combine affect of NS combination and varieties were non significant. Baber variety produced greater ear length (15.9 cm), while lower ear length (15.3 cm) was observed in Pahari. In case of N x $CaSO_4$ combination 160-20 kg ha$^{-1}$ produced maximum ear length (16.6 cm) and minimum ear length (14.6 cm) was recorded with the application of 160-0 kg N x $CaSO_4$ ha$^{-1}$. Significant affect was observed on ear length (cm) by varieties. NS combination affected ear length (cm). The probable reason could be that at favorable environment optimum utilization of solar light, higher assimilates production and its conversion to starches resulted higher grains number as reported by Derby *et al*., (2004). Ear length (cm) was not affected by the interaction of NS combination and varieties. Our results are also similar with Rozas *et al*., (2008), they stated that 150 kg ha$^{-1}$ nitrogen gives higher ear length then 60, 90 120 kg N ha$^{-1}$.

Table 3.Ear length (cm) of maize as affected by nitrogen and hydrated calcium sulphate ($CaSO4.2H_2O$)

| NS (Kg ha$^{-1}$) | Varieties | | Mean |
|---|---|---|---|
| | Baber | Pahari | |
| 120-0 | 16.3 | 14.3 | 15.3ab |
| 160-0 | 14.4 | 14.9 | 14.6b |
| 200-0 | 15.7 | 14.7 | 15.2ab |
| 120-20 | 15.6 | 14.3 | 15.0ab |
| 160-20 | 16.8 | 16.3 | 16.6a |
| 200-20 | 16.5 | 15.3 | 15.9ab |
| 120-40 | 16.3 | 16.2 | 16.3ab |
| 160-40 | 15.8 | 16.3 | 16.1ab |
| 200-40 | 15.7 | 15.9 | 15.8ab |
| Mean | 15.9a | 15.3b | |

**Grains ear$^{-1}$**

Data pertaining grain ear$^{-1}$ are shown in Table 4. Analysis of the data indicated that grain ear$^{-1}$ was significantly affected by varieties and interaction between N x $CaSO_4$ combination and varieties, while N x $CaSO_4$ combination was non significant. Baber variety produced higher grains (422) while lower grains (413) were produced in Pahari. In case of interaction between N x $CaSO_4$ combination and varieties maximum grains (436) were recorded in Pahari with application of 120-20 kg N x $CaSO_4$ ha$^{-1}$, while minimum grains (392) was recorded from Pahari with application of 200-0 kg NS ha$^{-1}$. Significant effect was observed due to varieties on grain ear$^{-1}$. NS combination also affected grain ear$^{-1}$. The probable reason could be that at favorable environment optimum utilization of solar light, higher assimilates production and its conversion to starches resulted higher grains number reported by Derby *et al*., (2004). Grains ear$^{-1}$ increases up to the application of optimum level of hydrated calcium sulphate and nitrogen and then decrease with further increase of hydrated calcium sulphate and nitrogen levels as reported by Balko and Russel (1980); Aulakh and Chhibba (1991) Our results are in agreement with Rozas *et al*., (2008) they stated that 120 kg ha$^{-1}$ nitrogen gives higher grain ear$^{-1}$ then 60, 90 150 kg N ha$^{-1}$.

Table 4. Grains ear$^{-1}$ of maize as affected by nitrogen and hydrated calcium sulphate ($CaSO4.2H_2O$)

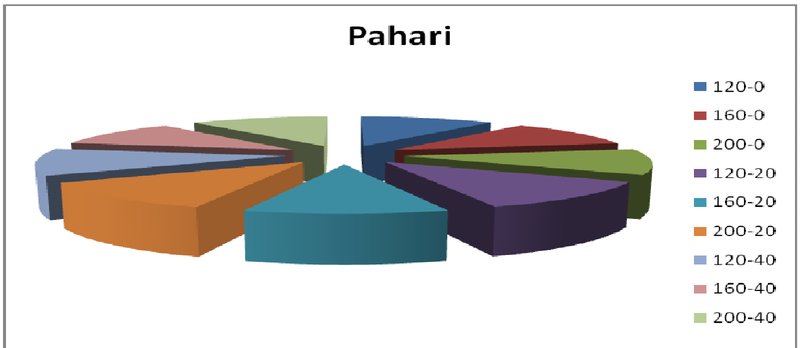
| NS (Kg ha$^{-1}$) | Varieties | | Mean |
|---|---|---|---|
| | Baber | Pahari | |
| 120-0 | 406 | 420 | 413abc |
| 160-0 | 421 | 406 | 413abc |
| 200-0 | 442 | 392 | 417abc |
| 120-20 | 412 | 436 | 424ab |
| 160-20 | 427 | 414 | 421abc |
| 200-20 | 422 | 394 | 408bc |
| 120-40 | 427 | 427 | 427a |
| 160-40 | 420 | 416 | 418abc |
| 200-40 | 404 | 403 | 404c |
| Mean | 422a | 413b | |

**Thousand grains weight (g)**

Data concerned thousand grain weight are revealed in Table 5. Statistical analysis of the data indicated significant effect of varieties, nitrogen and hydrated calcium sulphate combination and its interaction. Maximum thousand grains weight (274 g) was recorded in Pahari variety, while minimum was recorded in Baber (265 g). In case of N x $CaSO_4$ combination higher thousand grains weight (279g) was recorded with the application of 120-40 kg NS ha$^{-1}$, while lower thousand grains weight (257g) were recorded in treatment 200-0 kg N x $CaSO_4$ ha$^{-1}$. In case of interaction between NS combination and varieties greater thousand grains weight (293 g) were recorded in Pahari with application of 160-40 kg N x $CaSO_4$ ha$^{-1}$, while lesser thousand grains weight (259 g) in Baber with application of 120-0 kg N x $CaSO_4$ ha$^{-1}$. Varieties and NS combination significantly affected thousand grains weight (g). In case of varieties it might be due to the difference in genetic potential of these varieties. Optimum utilization of solar light, higher assimilates production and its conversion to starches resulted higher weight reported by Derby *et al*., (2004). The interaction between varieties and NS combination had significant affect on thousand grain weights. These results are similar with the findings of Leghra *et al*. (1999) they reported that S when applied at the rate of 30 kg ha$^{-1}$ significantly increased the thousand grain weight.

Table 5.Thousand grains weight (gm) of maize as affected by nitrogen and hydrated calcium sulphate ($CaSO4.2H_2O$)

| NS (Kg ha$^{-1}$) | Varieties | | Mean |
|---|---|---|---|
| | Pahari | Baber | |
| 120-0 | 259 | 267 | 263cd |
| 160-0 | 265 | 271 | 268abcd |
| 200-0 | 256 | 259 | 257d |
| 120-20 | 281 | 263 | 272abcd |
| 160-20 | 260 | 266 | 263cd |
| 200-20 | 278 | 278 | 278ab |
| 120-40 | 267 | 292 | 279a |
| 160-40 | 256 | 293 | 275abc |
| 200-40 | 264 | 265 | 264bcd |
| Mean | 265b | 274a | |



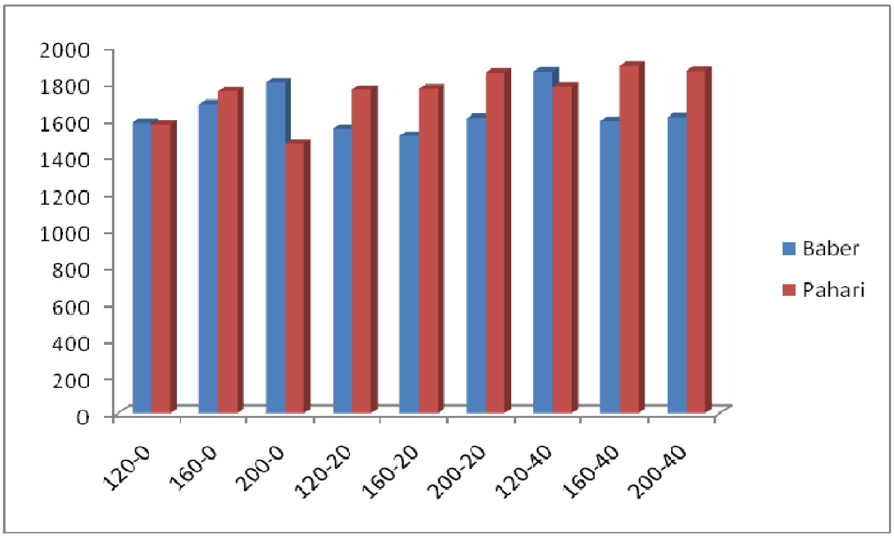

**Grains yield (kg ha$^{-1}$)**

Data pertaining grain yield are shown in Table 6. Analysis of the data indicated that grain yield was significantly affected by varieties, N x $CaSO_4$ combination and interaction between NS combination and varieties. Pahari variety produced higher grain yield (1731 kg $ha^{-1}$), while lower grain yield (1647 kg $ha^{-1}$) were produced in Baber. In case of N x $CaSO_4$ combination maximum grain yield (1819 kg $ha^{-1}$) were produced with application of 120-40 kg N x $CaSO_4$ $ha^{-1}$ while minimum grain yield (1576 kg $ha^{-1}$) were produced with application of 120-0 kg NS $ha^{-1}$. In case of interaction between N x $CaSO_4$ combination and varieties higher grain yield (1891 kg $ha^{-1}$) were recorded in Pahari with application of 160-40 kg N x $CaSO_4$ $ha^{-1}$, while lesser grain yield (1510 kg $ha^{-1}$) in Baber with application of 160-20 kg N x $CaSO_4$ $ha^{-1}$. Significant affect was observed on grains yield (kg $ha^{-1}$) due to varieties. It might be due to difference in the genetic potential of these varieties. NS combination and interaction between varieties and NS combination affected grain yield (kg $ha^{-1}$). The increase in grain yield kg $ha^{-1}$ as a result of increasing N and S application is attributed to enhanced crop growth rate, net assimilation rate which ultimately increased grain yield (kg $ha^{-1}$). Higher grain yield (kg $ha^{-1}$), in response to N and S application was also stated by Rasheed *et al.* (2003). Our results are similar with the findings of Sakal *et al.* 2000; Haq *et al.* 1989. Those stated that grains yield increases with increasing of S levels up to 60 kg $ha^{-1}$ and with further increase grains yield decreases.

Table 6. Grains yield (kg $ha^{-1}$) of maize as affected by nitrogen and hydrated calcium sulphate (CaSO4.2$H_2O$)

| NS (Kg $ha^{-1}$) | Varieties | | Mean |
|---|---|---|---|
| | Pahari | Baber | |
| 120-0 | 1581 | 1571 | 1576b |
| 160-0 | 1682 | 1753 | 1718ab |
| 200-0 | 1802 | 1468 | 1635b |
| 120-20 | 1547 | 1762 | 1655ab |
| 160-20 | 1510 | 1767 | 1638ab |
| 200-20 | 1607 | 1854 | 1730ab |
| 120-40 | 1860 | 1778 | 1819a |
| 160-40 | 1591 | 1891 | 1741ab |
| 200-40 | 1611 | 1863 | 1737ab |
| Mean | 1647b | 1731a | |




**Conclusion and Recommendations**

On the basis of above results it was concluded that higher grain yield (1819 kg $ha^{-1}$) and thousand grains weight (279 g) were recorded with the application of 120-40 kg N x $CaSO_4$ $ha^{-1}$. Delayed days to tasseling (58.8) and silking (63.5) were observed at 200-0 kg N x $CaSO_4$ $ha^{-1}$. Higher days to tasseling (57.6 days), silking (63.5 days), thousand grains weight (278 g) and grain yield (1730 kg $ha^{-1}$) were recorded in Pahari variety while Baber variety produced higher grains (422) $ear^{-1}$ and ear length(15.9 cm). 40-120 kg N x $CaSO_4$ $ha^{-1}$ produced high yield. It is recommended that cultivars Pahari should be grown for higher production and to increase water infiltration rate in hilly area of swat with the application f Hydrated Calcium sluphate ($CaSO_4$.2$H_2O$) and nitrogen at the rate of 160-40 kg $ha^{-1}$.

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