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# BALANCED USE OF NUTRIENTS FOR SUSTAINING HIGHER PRODUCTION OF PEARL MILLET IN ALLUVIAL SOIL

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## ABSTRACT

*A field experiment was conducted at farmers field at Panwari (Agra) during rainy seasons of 2010 and 2011 to study the effect of balanced use of nutrients on yield, uptake of nutrients and economics of pearl millet ( Pennisetum glaucum) in alluvial soil. The experiment was conducted in randomized block design with six treatments comprising different levels of N,P K with Zn and S. Application of 90 kg N ha$^{-1}$ as farmers fertilizer practice produced lowest grain (2.58 t ha$^{-1}$) and stover (6.49 t ha$^{-1}$) yields. Increasing NPK levels up to 150 % level increased the yield by 37.2 and 22.3 and 10.6and 11.5% over farmers practice and state recommendation, respectively. Application of 150 % NPK + 20 kg S+ 4 kg Zn ha$^{-1}$ produced the highest grain (4.03 t ha$^{-1}$) and stover (10.47 t ha$^{-1}$ ) yield , which increased by25.9 and 29.7 % over SR ( $N_{100}$,$P_{40}$, $K_{40}$) and farmers practice ($N_{90}$), respectively. Application of 150 % NPK+ 20 Kg S + 4 kg Zn ha$^{-1}$ provided the highest net monetary returns of Rs.32998 ha$^{-1}$ and B:C ratio of 2.48 in pearl millet crop. The uptake of nutrients by the crop improved with NPK levels and maximum values were recorded under 150% NPK+ S +Zn treatment. The crop grown in farmers practice utilized the lowest amounts of various nutrients. The fertility status of post harvest soil increased with increased levels of NPK and maximum values of organic carbon (4.5 g kg $^{-1}$), available N ( 240 kg ha $^{-1}$ ), P (18 kg ha $^{-1}$ ), K ( 150 kg ha $^{-1}$) S (12.5 mg ha $^{-1}$ ) and Zn (0.6 mg ha $^{-1}$) were recorded with 150 % NPK+S + Zn over other treatments. Omission of S and Zn caused a reduction in Soil S and Zn status over initial values.Thus balanced use of fertilizers not only provided higher productivity but also sustained the soil fertility.*

**Keywords**: Balanced use of nutrients, productivity, nutrient uptake, economics, pearl millet

## INTRODUCTION

Pearl millet (Pennisetum *glaucum L.*) is the fourth most important cereal and widely grown in India because of its tolerance to drought, high temperature and low soil fertility. Pearl millet grain is the staple diet and nutritious source of vitamins, minerals and protein, while pearl millet stover is a valuable livestock feed. Pearl millet is a heavy nutrient feeder and leads to large withdrawal of plant nutrients from soil. This depletion will result in decline in yield of the crop. Among various nutrients, sulphur and zinc play a crucial role in pearl millet production. Sulphur is now recognized as fourth element, whose deficiency is wide spread in India. Results of TSI-FAI-IFA project showed that, on an average, 46 % of cropped soils were deficient in sulphur and another 30% are potentially deficient (Morris, 2006). Sulphur deficiency is observed primarily due to high crop yield and therefore higher rates of S removal by crop and lesser use of S containing fertilizers. Zinc plays a key role as a structural constituent or regulatory cofactors of wide range of different enzymes and protein in many important biochemical pathways. These are mainly concerned with carbohydrate metabolism, both in the conversion of sugars to starch, protein metabolism, auxin (growth regulator) metabolism, pollen formation the maintenance of the integrity of biological membranes, the resistance to infection by certain pathogens. Zinc deficiency is a common phenomenon in cereals, particular in coarse treatment, soil semi arid regions. Balanced fertilization is the key to achieve higher productivity and nutrient use efficiency. There is a growing deficiency of macro and micro nutrients due to intensive cropping with use of high analysis fertilizers. Proper soil diagnosis and adoption of site specific nutrient and crop management ushers in highest productivity, efficiency and profitability. The concept of balanced fertilizations paves the way for optimum plant nutrient supply to realize full yield potential of crop. Keeping in view, an experiment was conducted to study the effect of balanced use of nutrients on yield, uptake of nutrients and economics of pearl millet.

## MATERIALS AND METHODS

Field experiment at farmer's field was conducted during rainy (kharif) season of 2010 and 2011 at Panwari village (Agra). Physico – chemical characteristics of the experimental soil was sandy loam texture, alkaline in reaction (7.8), low in organic carbon (3.2 gkg$^{-1}$), available N (147 kg ha$^{-1}$), available P (8.5 kg ha$^{-1}$), available K (115 kg ha$^{-1}$), available S (8.0 mg kg$^{-1}$) and available Zn (0.55 mg kg$^{-1}$). The treatments namely $T_1$ farmer fertilizer

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practice(90 kg N $ha^{-1}$), $T_2$ 100 % NP(100+40 kg $ha^{-1}$), $T_3$ 100% NPK (100+40+40 kg $ha^{-1}$), $T_4$ 150 % NPK (150+60+60 kg $ha^{-1}$), $T_5$ (150% NPK + 20 kg S+ 4 kg Zn $ha^{-1}$), $T_6$ 150% NP + 20 kg S + 4 kg Zn $ha^{-1}$ were replicated four times in randomized block design. Fertilizer sources for N,P and K were urea, single super phosphate and muriate of potash, respectively. Half nitrogen and total quantity of P and K were applied at the time of sowing, while remaining N was applied after one month of sowing. Pearl millet (var. – Pioneer 86 M 86) was sown @5 kg $ha^{-1}$ in first week of July in 2010 and 2011 and harvested in October in the same year. All improved packages of practices were followed to raise the crop. Grain and stover yields of pearl millet were recorded at harvest. Grain stover samples of the crop collected at harvest were analyzed for their N content by modified Kjeldahl method (Jackson, 1973). Phosphorus was determined by molybdovanadate yellow color method in di-acid ($HNO_3$ and $HClO_4$) extract. Potassium in acid extract was determined by flame photometer, S by turbidimetric method (Chesnin and Yien, 1951) and zinc by atomic absorption spectrophotometer. The uptake of nutrients was calculated by using grain and straw yield data. Economics of pearl millet with varying treatments was worked out on the basis of prevailing market prices of inputs and produce. The soil samples collected after harvest of the crop were analyzed for organic carbon, available N, P and K (Jackson 1973), available S (Chesnin and Yien 1951) and DTPA – Zn (Lindsay and Norvell 1978).

## RESULTS AND DISCUSSION

### Crop productivity

The yield of pearl millet grain ranged from 2.58 t $ha^{-1}$ under farmers fertilizer practice to as high as 4.03 t $ha^{-1}$ under balanced use of fertilizers ( 150% NPK + 20 kg S + 4kg Zn $ha^{-1}$). The balanced fertilizers treatment, wherein nutrient were applied not only to meet the crop demands but also to avoid any mining from soil reserve, outyielded by 56.2 and 61.3 % over FFP. The mean yield difference of 0.49 t $ha^{-1}$ between 150% NPK and 150% NPK + S+ Zn was partly ascribed to inclusion of S and Zn (Table 1). The extremely low available K content of the experimental soil was very much reflected in crop performance and also in yield response to K fertilizer. Inclusion of 40 kg $K_2O$ $ha^{-1}$ alone in state recommendation of N and P produced an additional grain yield of 0.27 t $ha^{-1}$. Like grain yield, stover yield was also significantly affected by the different treatments under study. The highest stover yield of 10.47 t $ha^{-1}$ was recorded with 150 % NPK + 20 kg S + 4 kg Zn $ha^{-1}$ followed by 9.00 t $ha^{-1}$ in 150 % NPK alone. Lowest stover yield (6.49 t $ha^{-1}$) was recorded in farmers practice. The higher yield of pearl millet seemed to be the cumulative effect of yield attributes which was boosted by balanced nutrient supply. These clearly indicate that the highest crop response in terms of yield was found with balkanced application of fertilizers.These findings are supported by those of Parihar *et al.* (2010), Dwivedi *et al.* 2011 and Sabin Ahmad *et al.* (2014) and Parasivan *et al.*(2014). Application of 20 kg S+4 kg Zn $ha^{-1}$ was beneficial for enhanced crop productivity. These elements produced higher grain and stover over 100% and 150% NPK alone. Thus, the balalnced use fertilizer in combination with S and Zn is necessary for sustaining productivity. Singh and Majumdar (2012) and Singh *et al.* (2014) also reported similar findings.

Table 1**:** Response and economics of pearl millet to balanced use of nutrient (mean of two years)

| Treatment | Grain yield (t $ha^{-1}$) | Stover yield (t $ha^{-1}$) | % response grain yield | Net Return (Rs $ha^{-1}$) | B:C ratio |
|---|---|---|---|---|---|
| FP (90 kg N) | 2.58 | 6.49 | -- | 20260 | 2.28 |
| 100 % NP(100+40) | 2.93 | 7.36 | 13.5 | 22405 | 2.32 |
| 100%NPK (100+40+40) | 3.20 | 8.07 | 24.0 | 26014 | 2.38 |
| 150 % NPK(150+60+60) | 3.54 | 9.00 | 37.3 | 28127 | 2.42 |
| 150 % NPK+ 20 kg S+ 4 kg Zn$ha^{-1}$ | 4.03 | 10.47 | 55.1 | 32988 | 2.48 |
| 150% NP+S+Zn | 3.57 | 9.01 | 38.3 | 28600 | 2.25 |
| CD (P=0.05) | 0.08 | 0.11 | | | |

### Uptake of nutrients

Successive increase in fertilizer levels upto 150% RDF significantly increased N, P and K uptake by pearl millet grain and stover (Table 2). The increases in N uptake due to 150% NPK were 51.2 and 15.7 % in grai and 58.8 and 16.3 % in stover over the farmers practice and 100% NPK, respectively. The corresponding increases in P uptake were 70.4 and 22.9 % in grain and 89.6 and 34.1 % in stover. Likewise, the increase in K uptake due to 150% NPK was to the tune of 47.0 and 14.4 % in grain and 43.2 and 13.2 % in stover over the farmers

practice and 100% NPK, respectively. The nutrient uptake is a function of yields and nutrient concentrations in the plant. Thus, significant improvement in uptake of N, P and K might be attributed to higher yields and increased concentrations in grain and stover under 150 % NPK. Our findings confirm the results of Dwivedi *et al.* (2011). Treatment 100% NP applied to pearl millet was also significantly better than the farmer practice in improving N,P and K uptake by pearl millet grain and stover.

Table 2: Uptake of N,P,K,S ( kg $ha^{-1}$) and Zn g $ha^{-1}$ by pearl millet crop (mean of two years)

| Treatment | Nitrogen | | Phosphorus | | Potassium | | Sulphur | | Zinc | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Grain | Stover | Grain | Stover | Grain | Stover | Grain | Stover | Grain | Stover |
| FP | 41.8 | 27.9 | 4.4 | 5.8 | 15.5 | 156.2 | 4.0 | 4.9 | 60.9 | 199.3 |
| 100 % NP | 49.5 | 33.7 | 5.6 | 7.4 | 17.4 | 175.5 | 4.9 | 5.9 | 69.8 | 227.9 |
| 100%NPK | 54.6 | 38.1 | 6.1 | 8.2 | 20.0 | 197.5 | 5.0 | 6.9 | 76.9 | 251.4 |
| 150 % NPK | 63.2 | 44.3 | 7.5 | 11.0 | 22.8 | 223.7 | 6.6 | 8.6 | 87.1 | 287.2 |
| 150%NPK+S+Zn | 71.6 | 52.5 | 8.7 | 12.5 | 25.7 | 261.5 | 8.7 | 12.3 | 113.7 | 384.1 |
| 150% NP+S+Zn | 64.4 | 49.0 | 7.6 | 10.6 | 21.2 | 230.2 | 8.0 | 11.1 | 102.0 | 354.6 |
| CD(P=0.05) | 1.41 | 1.63 | 0.25 | 0.41 | 0.43 | 5.9 | 0.27 | 0.75 | 5.08 | 18.90 |

Addition of 150 % NPK also significantly improved the uptake of S and Zn by pearl millet grain and stover. Addition of 20 kg S + 4 kg Zn $ha^{-1}$ along with 150 % NPK recorded maximum S and Zn uptake by grain and stover over other treatments. Increased uptake of S and Zn may be due to increase in concentrations of these nutrients in grain and stover yield. Singh *et al.* (2014) also reported similar results. Integration of S and Zn with 150% NPK resulted in the maximum uptake of nutrients over rest of the treatments. This may probably be due to enhanced nutrient availability and higher grain and stover yield of pearl millet (Singh *et al.* 2014).

**Soil fertility**

Organic carbon content varied from 3.1 to 4.5 $gkg^{-1}$ and maximum value was recorded with 150% NPK+20 kg S+4 kg Zn $ha^{-1}$ treatments.This increase in organic carbon might be due to improvement in root and shoot growth and thus higher production of biomass, which in turn, increased the organic carbon content in soil ( Sabina Ahmed *et al.* 2014). Available N, P, K, S and Zn status of post harvest soil was significantly higher than farmers practice under almost all the treatments. Improvement in N,P and K status was noted due to increase in the rate of NPK from 100 to 150 % recommended dose. Available N content ranged from 145 to 240 kg $ha^{-1}$ and that the highest value of available N was found associated with 150 % NPK + 20 kg S + 40kg Zn $ha^{-1}$. A reduction in available P content observed in farmer's fertilizer practice occurred due to removal of P by the crop in the absence of P supplementation through external source. A marked build up of available P status of soil was observed under 150 % NPK +20 kg S+ 4 kg Zn $ha^{-1}$ treatment. In the plots treated with 100% NP, the available K decreased by 23 kg $ha^{-1}$ over 100% NPK treatment. The maximum decline was observed in case of farmer fertilizer practice followed by 100% NP and 150% NP+20 kg S + 4 kg Zn $ha^{-1}$. This reduction in available K may be due to omission of K. The increases in available S and Zn with 150 % NP+S+Zn and 150% NPK + S + Zn were 0.12 and 0.14 mg $kg^{-1}$, respectively. Over 150 % NPK Improvement in the status of available S and Zn in soil after harvest of the crop were due to addition of these nutrients through the application of chemical fertilizers. Available S and Zn status of the soil reduced in the soil from their initial status in S and Zn free treatments.

Table 3: Effect of various treatments on available nutrients in post harvest soil

| Treatments | Org.Carbon (g $kg^{-1}$) | Nitrogen (kg $ha^{-1}$) | Phosphorus (kg $ha^{-1}$) | Potassium (kg $ha^{-1}$) | Sulphur (mg $kg^{-1}$) | Zinc (mg $kg^{-1}$) |
|---|---|---|---|---|---|---|
| FP | 3.1 | 145 | 8.2 | 105 | 7.5 | 0.52 |
| 100 % NP | 3.4 | 197 | 12.0 | 107 | 7.8 | 0.53 |
| 100%NPK | 3.6 | 205 | 13.5 | 130 | 8.2 | 0.53 |
| 150 % NPK | 3.9 | 232 | 15.7 | 142 | 8.5 | 0.54 |
| 150%NPK+S+Zn | 4.5 | 240 | 18.0 | 150 | 12.5 | 0.68 |
| 150% NP+S+Zn | 4.2 | 235 | 15.0 | 120 | 12.0 | 0.66 |
| CD (P=0.05) | 0.18 | 9.5 | 2.1 | 7.5 | 1.5 | 0.12 |

**Economics**

The net returns and benefit cost ratio obtained from pearl millet were significantly affected by doses of fertilizers applied to pearl millet crop (Table 1). Application of 150 % NPK resulted in significantly higher net returns of Rs.28127 $ha^{-1}$ with higher B:C ratio (2.42) over the farmers practice and 100 % NPK. Application of 150 % NPK + 20 kg S + 4 kg Zn $ha^{-1}$ resulted significantly higher net returns (Rs. 32988 $ha^{-1}$) with higher benefit:cost ratio (2.48) and fetched additions net returns of Rs. 4871 $ha^{-1}$ over 150 % NPK. Depletion of K (150 % NP + 20 kg S + 4 kg Zn $ha^{-1}$) resulted in significantly lower net returns of Rs.28600 $ha^{-1}$ over 150 % NPK + 20 kg S + 4 kg Zn $ha^{-1}$ treatment.The highest returns under 150% NPK + 20 kg S+ 4 kg Zn $ha^{-1}$ might be owing to more yields of pearl millet which led to proportionally higher gross returns than cost of cultivation. Minimum net returns and benefit: cost ratio was observed under farmer's practice which may be attributed lowest yields of pearl millet.

It may be concluded from the present investigation that 150 kg N+ 60 kg $P_2O_5$+ 60 kg $K_2O$ +20 kg S + 4 kg Zn $ha^{-1}$might be beneficial under semi arid condition of Agra region of Uttar Pradesh for achieving higher productivity and profitability of pearl millet besides maintaining soil fertility.

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