

Original Research Article

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## Influence of Nitrogen and Potassium Levels on Plant Water Status, Yield and Economics of Little Millet (*Panicum sumatrense*) Under Rainfed Condition

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### ABSTRACT

#### Keywords

Grain yield, Little millet, Relative Water content, Economics.

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A field investigation was conducted during *Kharif* -2016 at AICRP on Dryland Agriculture, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka to study the influence of nitrogen and potassium levels on plant water status, yield and economics of little millet (*Panicum sumatrense*) under rainfed condition. The experiment was laid out in Randomized complete block consisting of twelve treatments of different combination of nitrogen (3) and potassium (4) replicated thrice. Significantly higher relative water content (RWC) was maintained with application of 40 kg N and 20 kg K<sub>2</sub>O ha<sup>-1</sup> (78.3, 73.2 and 46.8 %, respectively) at 40, 60 DAS and at harvest as compared to 20 kg N and 0 kg K<sub>2</sub>O ha<sup>-1</sup> (63.3, 58.9 and 36.9 %, respectively). The maintenance of higher water in plant resulted in higher grain yield (730 kg ha<sup>-1</sup>), net income (₹ 20107 ha<sup>-1</sup>) and B: C ratio (2.30) with 40 kg N and 20 kg K<sub>2</sub>O ha<sup>-1</sup> as compared to all other treatments.

### Introduction

Recently, there has been increasing recognition of millets in view of quality of food, lower input and cost of production, wider adjustability to climate, soil *etc.*

Among the millets, little millet is one known by many regional names viz., *Kutki*, *Gundli* (Hindi), *Suan* (Oriya), *Saame* or *Saave* (Kannada), *Sumai* (Tamil) in different parts of the country. Cultivation of little millet is mostly confined to hilly tract and poor tribal communities of the country. It is also cultivated in plains by non-tribals in southern states in India.

Poor soil fertility and erratic rains are the most important constraints to crop production in rain fed ecosystem. Soil fertility management i.e. nutrient management particularly nitrogen and potassium plays a major role in increasing production and productivity of little millet. Nitrogen is an essential nutrient and key limiting factor in crop production. It is considered as one of the most important plant nutrients for growth and development of crop plant. It also plays an important role in synthesis of chlorophyll and amino acids that contribute to photosynthesis for better growth and protein metabolism in

plants. Potassium is an essential macro nutrient required for proper plant growth. It is involved in large number of physiological processes like osmo-regulation, cation–anion balance, protein synthesis and activation of enzymes. Being a major inorganic solute, it plays a key role in the plant water balance. It also reduces lodging, imparts disease, pest and drought resistance, and improves quality and self-life of the produce (Sharma and Agarwal, 2002).

Efficient and balanced fertilizer management plays an important role in increasing crop yield through efficient utilization of limited moisture /water supply by adjusting the crop growth and tolerance level to drought condition. Therefore, an attempt was made to assess the influence of nitrogen and potassium levels on plant water status and yield in little millet.

### **Materials and Methods**

A field experiment was conducted during *Kharif* 2016 at ACIRP on Dryland Agriculture, UAS, GKVK, Bengaluru, Karnataka, India on red sandy loam soil situated in Eastern Dry Zone of Karnataka at a latitude of 12° 58' N and longitude of 75° 35' E with an altitude of 930 meter above mean sea level. The soil type of experimental site was red sandy loam in texture, which is deep and possesses good drainage with a slightly acidic soil reaction, low in organic C and available N, high in available P<sub>2</sub>O<sub>5</sub>, medium in available K<sub>2</sub>O. The field experiment was laid out in Randomized complete block design in factorial concept consisting of twelve treatment combinations of three N levels (20, 40 and 60 kg N ha<sup>-1</sup>) and four K levels (0, 10, 20 and 30 kg K<sub>2</sub>O ha<sup>-1</sup>). The field was prepared by repeated ploughing and harrowing. FYM was applied @ 6.25 t ha<sup>-1</sup> to all the treatments 15 days prior to sowing. The little millet (JK-8) was

sown at 30×10 cm spacing with seed rate of 7.5 kg ha<sup>-1</sup> on September 6<sup>th</sup> with monsoon rain. The full dose of N and K was applied as per the treatment, while P<sub>2</sub>O<sub>5</sub>@ 20 kg ha<sup>-1</sup> to all the treatments basally through urea, MOP and DAP. All agronomic practices are followed as per as package of practices of UAS Bengaluru. The relative water content (%) was worked out by Weatherly method at 20, 40, 60 DAS and at harvest as formula given below.

$$\text{RWC (\%)} = \frac{\text{Fresh weight (g)} - \text{Dry weight (g)}}{\text{Turgid weight (g)} - \text{Dry weight (g)}} \times 100$$

Free proline content in leaves was determined during severe dry spell at 60 DAS using the method of suggested by Bates *et al.*, (1973) and expressed in μmol g<sup>-1</sup> of fresh weight of leaves. The experimental data was subjected to analysis by using Fisher's method of "Analysis of Variance" (ANOVA) as outlined by Gomez and Gomez (1984). All the data were analyzed and the results are presented and discussed at a probability level of 0.05 per cent.

### **Results and Discussion**

#### **Effect of nitrogen and potassium on relative water content (%)**

Relative water content in little millet was influenced significantly with different levels of nitrogen and potassium. There was no significant difference observed in relative water content at 20 DAS with different levels of nitrogen and potassium.

With respect to nitrogen levels, the relative water content was significantly higher with application of nitrogen @ 40 kg ha<sup>-1</sup> (69.5 %) compared to 20 kg N ha<sup>-1</sup> (62.5 %) at 60 DAS and it was at par with the application of nitrogen @ 60 kg ha<sup>-1</sup> (70.4 %). Similar trend

was also noticed at 40 DAS and at harvest. With regard to potassium levels, the relative water content was significantly higher with the application of potassium @ 20 kg ha<sup>-1</sup> (70.01 %) compared to 0 kg K<sub>2</sub>O ha<sup>-1</sup> (63.1%) at 60 DAS and it was also at par with the application of potassium @ 30 kg ha<sup>-1</sup> (70.1%). Similar trend was noticed at 40 DAS and at harvest. In different combination of N and K levels, the relative water content was higher with the application of 40 kg N + 20 kg K<sub>2</sub>O ha<sup>-1</sup> (73.2 %) followed by 40 kg N + 30 kg K<sub>2</sub>O ha<sup>-1</sup> (72.3 %), 60 kg N + 20 kg K<sub>2</sub>O ha<sup>-1</sup> (72.1 %), 60 kg N ha<sup>-1</sup> + 30 kg K<sub>2</sub>O ha<sup>-1</sup> (71.9 %) at 60 DAS. Lower relative water content was recorded with the application of 20 kg N + 0 kg K<sub>2</sub>O (58.9%). Similar trend was also noticed at 40 DAS and at harvest. This was mainly because, the potassium is involved in osmotic adjustment by accumulating free proline in leaves (Table 1). Thus, K maintains higher relative water content and lower osmotic potential resulting in improved ability of plants to tolerate drought stress. This was confirmative with the findings of Kant and Kafkafi (2002).

Beringer (1978) reported that potassium being directly involved as an osmotic constituent and also regulates the synthesis of osmotically active organic solutes thereby having an impact on turgor potential. Mukherjee (1974) reported that potassium induces the free proline in leaf disc of maize. Udaykumar *et al.*, (1976) have also reported that enhanced free proline levels as a result of potassium treatment. Potassium induced proline has been noticed in *Pennisetum* (Huber 1984).

### **Effect of nitrogen and potassium on yield and yield parameters of little millet**

The yield parameters of little millet are varied due to different levels of nitrogen and potassium (Table 2). With respect to different N levels, significantly higher yield parameters

*viz.*, number of productive tillers m<sup>-1</sup> length, ear length and grain weight m<sup>-1</sup> length was noticed in the application of nitrogen @ 40 kg ha<sup>-1</sup> (54.2, 14.6 cm and 21.9 g, respectively) at harvest as compared to the application of nitrogen @ 20 kg ha<sup>-1</sup> (42.9, 11.3 cm and 16.9 g, respectively) and was on par with the application of nitrogen @ 60 kg ha<sup>-1</sup> (56.7, 15.2 cm and 22.5 g, respectively).

With respect to different K levels, significantly higher yield parameters *viz.*, number of productive tillers m<sup>-1</sup> length, ear length and grain weight m<sup>-1</sup> length was noticed with the application of potassium @ 20 kg ha<sup>-1</sup> (53.7, 14.5 cm and 21.7 g, respectively) at harvest as compared to the application of potassium @ 0 kg ha<sup>-1</sup> (46.9, 12.7 cm and 18.8 g, respectively) and was on par with the application of potassium @ 30 kg ha<sup>-1</sup> (53.5, 14.2 cm and 21.6 g, respectively). In different combination of N and K levels, the application of 40 kg N + 20 kg K<sub>2</sub>O ha<sup>-1</sup> registered the higher yield parameters *viz.*, number of productive tillers m<sup>-1</sup> length, ear length and grain weight m<sup>-1</sup> length (59.6, 16.1 cm and 23.4 g, respectively) followed by 60 kg N + 20 kg K<sub>2</sub>O ha<sup>-1</sup> (57.9, 15.6 cm and 23.3 g, respectively), 60 kg N + 30 kg K<sub>2</sub>O ha<sup>-1</sup> (57.6, 15.4 cm and 23.3 g, respectively), 60 kg N + 10 kg K<sub>2</sub>O ha<sup>-1</sup> (56.7, 15.3 cm and 22.2 g, respectively) and 40 kg N + 30 kg K<sub>2</sub>O ha<sup>-1</sup> (56.5, 15.2 cm and 21.9 g, respectively). Lower yield parameters were registered with the application of 20 kg N + 0 kg K<sub>2</sub>O ha<sup>-1</sup> (40.5, 10.7 cm and 14.4 g, respectively).

These higher yield parameters ultimately improve grain and straw yield in little millet (Table 2). Among different nitrogen levels, significantly higher grain and straw yield was observed with the application of nitrogen @ 40 kg ha<sup>-1</sup> (686 and 1243 kg ha<sup>-1</sup>, respectively) as compared 20 kg N ha<sup>-1</sup> (529 and 1042 kg ha<sup>-1</sup>, respectively).

**Table.1** Relative water content (%) and proline content in little millet as influenced by different levels of nitrogen and potassium

Treatments	20 DAS	40 DAS	60 DAS	At harvest	Proline content
<b>Nitrogen levels (N)</b>					
N <sub>1</sub> : 20 kg ha <sup>-1</sup>	61.9	67.0	62.5	39.3	49.8
N <sub>2</sub> : 40 kg ha <sup>-1</sup>	64.7	74.6	69.5	44.2	52.3
N <sub>3</sub> : 60 kg ha <sup>-1</sup>	65.4	75.4	70.4	44.8	52.4
S. Em.±	3.3	0.6	0.5	0.4	0.2
CD (p=0.05)	NS	1.6	1.6	1.1	0.6
<b>Potassium levels (K)</b>					
K <sub>1</sub> : 0 kg ha <sup>-1</sup>	60.0	67.9	63.1	39.8	50.0
K <sub>2</sub> : 10 kg ha <sup>-1</sup>	62.8	71.2	66.7	42.2	51.0
K <sub>3</sub> : 20 kg ha <sup>-1</sup>	65.7	74.9	70.0	44.6	52.7
K <sub>4</sub> : 30 kg ha <sup>-1</sup>	67.6	75.1	70.1	44.6	52.4
S. Em.±	3.8	0.6	0.6	0.4	0.2
CD (p=0.05)	NS	1.9	1.8	1.3	0.7
<b>Interaction (N × K)</b>					
N <sub>1</sub> K <sub>1</sub>	57.1	63.3	58.9	36.9	48.9
N <sub>1</sub> K <sub>2</sub>	61.2	64.7	60.2	37.8	49.1
N <sub>1</sub> K <sub>3</sub>	62.2	69.1	64.7	40.9	50.5
N <sub>1</sub> K <sub>4</sub>	67.0	70.8	66.1	41.8	50.9
N <sub>2</sub> K <sub>1</sub>	61.3	67.5	62.6	39.4	49.8
N <sub>2</sub> K <sub>2</sub>	63.5	74.8	69.9	44.5	51.8
N <sub>2</sub> K <sub>3</sub>	66.5	78.3	73.2	46.8	54.0
N <sub>2</sub> K <sub>4</sub>	67.4	77.6	72.3	46.1	53.6
N <sub>3</sub> K <sub>1</sub>	61.5	72.9	67.7	43.0	51.2
N <sub>3</sub> K <sub>2</sub>	63.7	74.2	70.0	44.3	52.1
N <sub>3</sub> K <sub>3</sub>	68.3	77.5	72.1	46.0	53.6
N <sub>3</sub> K <sub>4</sub>	68.3	77.0	71.9	45.9	52.7
S. Em.±	6.7	1.1	1.1	0.7	0.4
CD (p=0.05)	NS	3.2	3.2	2.2	1.2

CD: Critical difference; NS: Non- significant

**Table.2** Yield and yield parameters of little millet as influenced by different levels of nitrogen and potassium

Treatments	No of productive tillers m <sup>-1</sup>	Ear length (cm)	Grain weight m <sup>-1</sup> length (g)	1000 seed weight (g)	Grain yield (kg ha <sup>-1</sup> )	Straw yield (kg ha <sup>-1</sup> )
<b>Nitrogen levels (N)</b>						
N <sub>1</sub> : 20 kg ha <sup>-1</sup>	42.9	11.3	16.9	2.5	529	1042
N <sub>2</sub> : 40 kg ha <sup>-1</sup>	54.2	14.6	21.9	2.5	686	1243
N <sub>3</sub> : 60 kg ha <sup>-1</sup>	56.7	15.2	22.5	2.6	703	1258
S. Em.±	0.9	0.3	0.4	0.1	12	17
CD (p=0.05)	2.5	0.7	1.1	NS	34	50
<b>Potassium levels (K)</b>						
K <sub>1</sub> : 0 kg ha <sup>-1</sup>	46.9	12.7	18.8	2.5	588	1116
K <sub>2</sub> : 10 kg ha <sup>-1</sup>	50.8	13.5	19.7	2.5	615	1161
K <sub>3</sub> : 20 kg ha <sup>-1</sup>	53.7	14.5	21.7	2.6	678	1221
K <sub>4</sub> : 30 kg ha <sup>-1</sup>	53.5	14.2	21.6	2.5	675	1225
S. Em.±	1.0	0.3	0.4	0.1	13	19
CD (p=0.05)	2.9	0.8	1.3	NS	39	58
<b>Interaction (N × K)</b>						
N <sub>1</sub> K <sub>1</sub>	40.5	10.7	14.4	2.4	448	910
N <sub>1</sub> K <sub>2</sub>	40.9	10.5	15.1	2.4	471	981
N <sub>1</sub> K <sub>3</sub>	43.6	11.7	18.4	2.5	575	1107
N <sub>1</sub> K <sub>4</sub>	46.4	12.2	19.9	2.5	621	1168
N <sub>2</sub> K <sub>1</sub>	45.8	12.4	20.9	2.5	652	1212
N <sub>2</sub> K <sub>2</sub>	54.7	14.7	21.7	2.5	676	1235
N <sub>2</sub> K <sub>3</sub>	59.6	16.1	23.4	2.6	730	1282
N <sub>2</sub> K <sub>4</sub>	56.5	15.2	21.9	2.6	683	1244
N <sub>3</sub> K <sub>1</sub>	54.5	14.5	21.1	2.6	664	1227
N <sub>3</sub> K <sub>2</sub>	56.7	15.3	22.2	2.6	692	1259
N <sub>3</sub> K <sub>3</sub>	57.9	15.6	23.3	2.6	728	1275
N <sub>3</sub> K <sub>4</sub>	57.6	15.4	23.3	2.6	727	1272
S. Em.±	1.7	0.5	0.8	0.1	23	34
CD (p=0.05)	5.0	1.5	2.2	NS	68	100

CD: Critical difference; NS: Non- significant

**Table.3** Economics of little millet as influenced by different levels of nitrogen and potassium

Treatments	Cost of cultivation (Rs. ha <sup>-1</sup> )	Gross return (Rs. ha <sup>-1</sup> )	Net return (Rs. ha <sup>-1</sup> )	B:C ratio
N <sub>1</sub> K <sub>1</sub>	14705	21994	7289	1.50
N <sub>1</sub> K <sub>2</sub>	14887	23141	8254	1.55
N <sub>1</sub> K <sub>3</sub>	15074	28106	13032	1.86
N <sub>1</sub> K <sub>4</sub>	15255	30299	15044	1.99
N <sub>2</sub> K <sub>1</sub>	14955	31781	16826	2.12
N <sub>2</sub> K <sub>2</sub>	15137	32909	17404	2.14
N <sub>2</sub> K <sub>3</sub>	15324	35431	20107	2.30
N <sub>2</sub> K <sub>4</sub>	15505	33242	18105	2.19
N <sub>3</sub> K <sub>1</sub>	15199	32313	17114	2.13
N <sub>3</sub> K <sub>2</sub>	15381	33668	18287	2.19
N <sub>3</sub> K <sub>3</sub>	15568	35324	19756	2.27
N <sub>3</sub> K <sub>4</sub>	15749	35268	19519	2.24

N<sub>1</sub>: 20 kg ha<sup>-1</sup>  
 N<sub>2</sub>: 40 kg ha<sup>-1</sup>  
 N<sub>3</sub>: 60 kg ha<sup>-1</sup>

K<sub>1</sub>: 0 kg ha<sup>-1</sup>  
 K<sub>2</sub>: 10 kg ha<sup>-1</sup>  
 K<sub>3</sub>: 20 kg ha<sup>-1</sup>  
 K<sub>4</sub>: 30 kg ha<sup>-1</sup>

However, it was at par with the application of 30 kg N ha<sup>-1</sup> (703 and 1258 kg ha<sup>-1</sup>, respectively). Among different potassium levels, significantly higher grain yield was recorded with the application of potassium @ 20 kg ha<sup>-1</sup> (678 and 1221 kg ha<sup>-1</sup>, respectively) as compared to 0 kg K<sub>2</sub>O ha<sup>-1</sup> (588 and 1116 kg ha<sup>-1</sup>, respectively). However, it was at par with the application of 30 kg K<sub>2</sub>O ha<sup>-1</sup> (675 and 1225 kg ha<sup>-1</sup>, respectively).

With different combination of nitrogen and potassium levels, application of nitrogen @ 40 kg ha<sup>-1</sup> and potassium @ 20 kg ha<sup>-1</sup> recorded significantly higher grain and straw yield (730 and 1282 kg ha<sup>-1</sup>, respectively) as compared to 20 kg N + 0 kg K<sub>2</sub>O ha<sup>-1</sup> (448 and 910 kg ha<sup>-1</sup>, respectively).

But, it was at par with application of 60 kg N + 20 kg K<sub>2</sub>O ha<sup>-1</sup> (728 and 1275 kg ha<sup>-1</sup>, respectively), 60 kg N + 30 kg K<sub>2</sub>O ha<sup>-1</sup> (727 and 1272 kg ha<sup>-1</sup>, respectively) and 60 kg N + 10 kg K<sub>2</sub>O ha<sup>-1</sup> (692 and 1259 kg ha<sup>-1</sup>, respectively).

However, 1000 seed weight found non-significant result in all the treatments. These improved yield parameters resulted in grain and straw yield (Table 2). These improved yield parameters mainly because of application of potassium overcome the harmful effects of water stress, retaining water in tissue and thus maintaining higher plant growth and regulating transpiration (Ram Rao, 1986). Whereas, application of nitrogen influence the higher growth parameters and improves dry matter accumulation which in turn improves yield parameters (Bhanu Prasad Reddy *et al.*, 2016).

Later, this dry matter translocated to different yield components thereby increases grain yield (Table 2). Similar results are also reported by Krishna Sastry (1985) and Nandawal *et al.*, (1998).

### Economics

Higher gross return, net return and B: C ratio was recorded with the application of 40 kg N

and 20 kg K<sub>2</sub>O (Rs. 35431 ha<sup>-1</sup>, Rs. 20107 ha<sup>-1</sup> and 2.30, respectively) followed by 60 kg N and 20 kg K<sub>2</sub>O (Rs. 35324 ha<sup>-1</sup>, Rs. 19756 ha<sup>-1</sup> and 2.27, respectively), 60 kg N and 30 kg K<sub>2</sub>O (Rs. 35268 ha<sup>-1</sup>, Rs. 19519ha<sup>-1</sup> and 2.24, respectively). Lower gross return, net return and B: C ratio was recorded with the application of 20 kg N and 0 kg K<sub>2</sub>O (Rs. 21994 ha<sup>-1</sup>, Rs. 7289 ha<sup>-1</sup> and 1.50, respectively).

The higher gross return, net return and B: C ratio was due to higher grain yield which ultimately reflects higher B: C ratio (Table 3) associating with balanced nutrition. These results are in line with the findings of Bhomte *et al.*, (2016).

Balanced fertilization in little millet with 40 kg N and 20 kg K<sub>2</sub>O ha<sup>-1</sup> is essential for higher yield and better economics under rainfed condition.

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