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Influence of integrated nutrient sources and seed priming on growth seed yield and quality in Nutri-cereal Proso millet

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Abstract
Prosomillet [*Panicum miliaceum* L.] is a tetraploid crop (2n=4x=36) belonging to the grass family *Poaceae*. It is one of the oldest grain crops, which is rich in protein and iron than wheat or rice. Integrated application of organic manures, in conjugation with chemical fertilizers and bio-priming improves the physico-chemical properties of soil and maintains a feasible plant growth condition, thus augment the seed yield and quality. Keeping these views, the present investigation was undertaken during three seasons *Kharif* 2017, 2018 and 2019. The treatment combinations were arranged in Split Plot Design with three replications, which includes four nutrient management treatments as main-plots (N_1-without fertilizer, N_2-organic manures, N_3-chemical fertilizers and N_4-integrated application) and priming as sub-plots treatments (P_1-control, P_2- hydro-priming, P_3-chemo-priming and P_4-bio-priming). The direct sowing of proso millet with fertilizer dose 125 kg neem + 1250 kg vermi-compost per ha + 50 kg Urea + 50 kg SSP and 50 kg MOP per ha + top dressing urea at 3-4 weeks after transplanting + 2% borax spray at flowering stage enhanced the seed yield and quality in proso millet *cv.* TNAU-145. The resultant increase in the yield of N_4 (integrated application of organic and inorganic fertilizers) was to the extent of 44.76 per cent as against control (N_1). Seed priming with 20% liquid *Pseudomonas fluorescence* enhanced the yield of proso millet *cv.* TNAU-145 by 39.0 per cent. The combination of priming and fertilizer application enhanced the seed yield and quality of proso millet to a greater extent. Hence, combining seed priming and integrated fertilizer application offers the best growth and yield in proso millet.

Keywords: Integrated nutrient sources, proso millet, *Panicum miliaceum* L.

Introduction
Small millets may be defined as millets cultivated for their small grains, which are borne on short, slender grassy plants. They provide staple food for millions of people in the developing countries of world particularly in Africa and South Asia. The grains of small millets being nutritionally superior and provides cheap proteins, minerals and vitamins, where the need for such ingredients is maximum. The untapped seed yield potential coupled with nutritional superiority makes the small millets potential future food crops particularly in low rainfall area. Small millets are extraordinarily tolerant to drought and other abiotic stresses, such as high temperature and poor soil. This makes them "climate smart" and a good source for genetic traits that can strengthen the resilience of other crops in the face of climate change. Being a short duration crop with relatively low water requirement this escapes drought and therefore offers better prospects for intensive cultivation in dry land areas.
In India, small millets are cultivated over an area of 0.59 million ha with total production of 0.39 million tonnes and productivity of 654 kg per ha (Anon., 2016) [2]. The lower productivity of proso-millet is largely due to poor fertility of soils and non-adoption of improved cultivation practices. Nevertheless, these crops do have large hidden production potential, which could be exploited by judicial blending of varietal production and protection technologies. These crops respond very well even to small doses of inorganic fertilizers and other crop management inputs which do not involve additional expenditure such as sowing at optimum time, adopting proper method of sowing, maintenance of adequate plant stand, timely weeding and inter-cultivation. The lower productivity is also due to late sowing, improper methods of cultivation and little or less use of fertilizers. The secret of boosting its yields mainly lies in suitable planting method and properly fertilizing the crop.
Continuous use of inorganic fertilizers alone deteriorates soil health and lowers its productivity. In recent days, integrated approach of combined use of inorganic fertilizers with manures has become an established agro-technique for sustaining yield levels, enhancing nutrient quality of food and restoring soil physical, chemical and biological health. Seed priming is one among the seed quality enhancement technique, in which seeds are partially

hydrated until the germination process begins, but radicle emergence does not occur (Bradford, 1986) [5]. This technique is used for improvement of germination speed, germination vigour, seedling establishment and yield (Talebian *et al*., 2008) [8]. Application of organic manures, in conjugation with chemical fertilizers and bio-priming improves the physico-chemical properties of soil and maintains a feasible plant growth condition, thus augment the seed yield and quality. Keeping these in views, the present investigation on enhancing seed yield in prosomillet (*Panicum miliaceum* L.) through integrated nutrient approach was undertaken an objective to study the effect of integrated plant nutrients and priming techniques on plant growth and seed yield.

Material and Methods

The field experiments were carried out successively for three sowing seasons *viz.*, *kharif*, 2017, 2018 and 2019 at National Seed Project (Crops), UAS, GKVK, Bengaluru. Seeds having initial germination of 85 per cent were used for the study. The seed material was dried to safe level of moisture (10.0%), graded to uniform size by using 1.6 (R) screen size and then used for the study to avoid variations. Proso millet variety *TNAU-145* was selected for the study. It is a short duration profusely tillering variety highly suitable for dry lands of India. It yields on an average 1.8t per hectare and straw yield (4.6 t per ha).

The experiment was laid under Split Plot Design with three replications in 16 treatment combinations. The treatments comprised of four different levels of fertilizers as main treatments, N_1-control (without fertilizers); N_2- Organic manures on N equivalent basis (125 kg Neem cake + 1250 kg vermicompost/ ha); N_3- Chemical fertilizers (50 kg urea + 50 kg SSP and 50 kg MOP per ha + top dressing urea at 3-4 weeks after transplanting + 2% Borax) and N_4-Integrated application of organic and chemical fertilizers (125 kg Neem + 1250 kg vermi-compost per ha + 50 kg urea + 50 kg SSP and 50 kg MOP per ha + top dressing urea at 3 to 4 weeks after transplanting + 2% Borax).

Four methods of priming as sub-treatments, P_1– without priming (control); P_2 – Hydro-priming for 6 hours at 1:1 and shade drying for 24 hours before sowing; P_3 – Chemo priming with 2% KH_2PO_4 for 6 hours soaking in 1:1 and shade drying for 24 hours before sowing and P_4–Bio priming with (20%) liquid *Pseudomonas fluorescence* (2ml broth+8ml sterile water) in 1:1 ratio with seeds and shade drying for 24 hours before sowing. After imposing treatments, the crop was raised as per the standard cultural practices. Ten plants were selected randomly and tagged in each treatment for recording plant growth and yield parameters. The crop was harvested when two third of the seeds are ripe and then threshed by hand separately. Same procedure was followed for three seasons *viz.*, *kharif* 2017, 2018 and 2019. The observations on growth parameters, seed yield and seed quality parameters were recorded. The pooled analysis of three years' data was carried out for interpretation.

Results and Discussion

The data recorded on seed yield and quality were analyzed statistically and depicted in the table 1 & 2 which are discussed under the following headings

Influence of integrated nutrient sources on growth, yield and quality of nutria-cereal proso-millet

The nutrient management treatments significantly influenced the plant growth, seed yield and quality of proso millet *cv.* TNAU-145. The nutrient dosage N_4 (125 kg Neem + 1250 kg vermicompost per ha + 50 kg urea + 50 kg SSP and 50 kg MOP per ha + top dressing with urea at 3 to 4 weeks after transplanting + 2% Borax at flowering stage) showed superiority with respect to various growth parameters *viz.*, field emergence (81.64%), plant height (127.9 cm) and chlorophyll content (37.01 SPAD units), which accounts to an increase of 13.09%, 15.32% and 11.54% respectively against control (N_1) (Table 1). Early days to 50 per cent flowering (45.33 days) was also reported in the same treatment, which is due to combined use of organic manure and inorganic sources of nutrients where inorganic sources readily provides nutrients to the growing plants and organic sources on decomposition releases organic acids, which might have mobilized the native or non-exchangeable forms of NPK and charge the soil NPK ions, so that it may be readily available which might have increased the growth parameters Yaduvanshi (2003) [9]. These results are in accordance with the findings of Chintalapati Sravani (2016) [6] in finger millet.

The yield parameters *viz.*, number of tillers per hill (9.8), seed yield (26.32 g/plant; 1.453 kg/ plot & 14.52 q/ha) were also recorded highest in N_4 (125 kg Neem + 1250 kg vermicompost per ha + 50 kg urea + 50 kg SSP and 50 kg MOP per ha + top dressing with urea at 3 to 4 weeks after transplanting + 2% Borax at flowering stage). The resultant increase in the yield per hectare of N_4 (integrated application of organic and inorganic fertilizers) was to the extent of 44.76 per cent against control (N_1). These findings are in agreement with the results obtained by Anon. (2016) [2] and Chintalapati Sravani (2016) [6]. Organic fertilizers improve the soil physical and biological characteristics but contain lower levels of plant nutrients. They are combined with inorganic mineral fertilizers which readily meet the needs of plant for increment in yield, according to Adeyeye *et al*. (2014) [1].

Similarly, the seed quality significantly differed among various nutrient management treatments (Table 2). Significant highest germination (82.41%), test weight (5.891 g) and vigour (1586) was noted in N_4 (Integrated application of organic and inorganic fertilizers). The resultant increase in the germination and vigour was to the extent of 4.39 and 6.94 per cent, respectively. This is because, the soil nitrogen balance has increased with increase in application of nitrogen through different organic and inorganic fertilizers that might be attributed to the addition of more nitrogen into the soil, and its slow release throughout the crop growth period which might have minimized the nitrogen loss. The present result is also consistent with the findings of Anon. (2016) [2].

Influence of priming on growth, yield and quality of nutria-cereal proso-millet

The priming treatments significantly enhanced the growth, yield and quality of proso millet *cv.* TNAU-145. In general, enormous increase in field emergence per cent, growth and yield was witnessed among all the priming treatments as against control. Among the treatments, seed priming with 20% liquid *Pseudomonas fluorescence* for 6hrs by adopting seed to solution ratio of 1:1 recorded significant highest field emergence (80.88%), plant height (123.1cm) and chlorophyll content (36.26 SPAD units). The resultant increase in the field emergence of seeds treated with 20% liquid *Pseudomonas fluorescence* was to the extent of 11.34 per cent as against unprimed seeds (Table 1). This is due to the action of biocontrol agent *Pseudomonas fluorescence* which is involved in the production of plant growth regulators like indole acetic acid (IAA), gibberlic acid, cytokinins and ethylene. The bio

agent *Pseudomonas fluorescence* have several beneficial roles and possess properties of plant growth promotion. Auxins produced by *Rhizobacteria* can influence plant growth, including root development which improve uptake of essential nutrients thus increasing plant growth.

The yield parameters *viz.*, no. of tillers (9.1) and seed yield (24.88 g/plant; 1.373 kg/plot & 13.72 q/ha) was noted highest among seeds primed with 20% liquid *Pseudomonas fluorescence* (Table 1). Seed priming with 20% liquid *Pseudomonas fluorescence* enhanced the yield per hectare of proso millet *cv.* TNAU-145 by 39.0 per cent. The increased seed yield might be due to the higher physicochemical mechanisms triggering the biosynthesis of nucleic acids, proteins and the consequential enhancement of cell division besides the enhanced metabolic activity of the plants resulting in increased uptake of nutrients, according to Bharathi *et al.* (2004) [3]. Besides, yield, priming enhanced the resultant germination and vigor of the seeds. Highest germination (83.05%) and vigour (1627) was reported in P_4 which accounts to an increase of 5.64 and 14.65 per cent respectively against control. This might be the result of a synergism of priming effect with bacterial effect, since priming confirms benefits such as enhancing seed yield and quality in prosomillet (*Panicum miliaceum* L.) through integrated approach as completion of early germination phases, increasing the population of bio-protectants, rapid and uniform seedling emergence, facilitation of uptake of water and nutrients, protection against pathogens, potential defence responses such as early oxidation burst, incorporation of various phenolic compounds and polymers to the cell wall and secretion of phytoalexins, according to Sridevi and Manonmani (2016) [7]. Hence priming could be adopted to obtain uniform emergence, potential yield and quality in proso millet crop. These findings are in agreement with the results obtained by Sridevi and Manonmani (2017) [7] in proso millet.

Interaction effect of nutrient management treatments with seed priming on growth, yield and quality of nutria-cereal proso-millet

The interaction of nutrient management with seed priming was found significant for growth, yield and quality parameters of proso millet. Maximum field emergence (86.33%), chlorophyll content (40.06 SPAD units), plant height (135.1 cm), maximum number of tillers (10.8) and seed yield (30.67 g/plant; 1.788 kg/plot and 17.88 q/ha) was noted among the interaction P_4 x N_4 (priming of seeds with 20% *Pseudomonas fluorescence* and supply of inorganic and organic fertilizers in combination along with borax spray) (Table 1). While, lowest seed yield (15.83 g/plant; 0.849 kg/plot and 8.49 kg/ha) was recorded among control (P_1 x N_1). The resultant quality *viz.*, germination (84.77%) and vigour (1706) was noted highest in the same treatment combination (Table 2).

Table 1: Effect of nutrient management and seed priming on plant growth and seed yield of proso millet *cv.* TNAU-145

Treatment	Field emergence (%)	50% flowering	Chlorophyll content (SPAD values)	Plant height (cm)	Number of tillers plant^{-1}	Seed yield (g/plant)	Seed yield/plot (kg)	Seed yield/ha (q)
Nutrient management								
N_1	72.19	47.75	33.18	110.9	7.9	19.11	1.003	10.03
N_2	75.03	46.97	34.54	110.1	7.8	19.28	0.952	9.51
N_3	77.72	45.72	36.41	123.9	8.2	22.70	1.280	12.79
N_4	81.64	45.33	37.01	127.9	9.8	26.32	1.453	14.52
S.Em±	0.245	0.277	0.245	3.43	0.296	0.988	0.075	0.749
CD(0.05P)	0.728	0.823	0.728	10.190	0.879	2.935	0.223	2.225
Priming								
P_1	72.64	46.89	35.35	113.0	7.9	18.61	0.988	9.87
P_2	75.11	46.72	33.83	117.4	7.9	20.98	1.112	11.12
P_3	77.94	46.03	35.71	119.4	8.8	22.94	1.215	12.15
P_4	80.88	46.14	36.26	123.1	9.1	24.88	1.373	13.72
S.Em±	0.145	0.097	0.326	0.68	0.199	0.434	0.039	0.394
CD(0.05P)	0.431	0.288	0.968	2.020	0.591	1.289	0.116	1.171
Interaction (N x P)								
P_1 x N_1	68.89	48.67	33.17	106.9	7.4	15.83	0.849	8.49
P_1 x N_2	70.67	48.33	33.12	108.6	7.6	19.54	0.978	9.78
P_1 x N_3	73.00	46.33	33.15	112.0	8.4	20.60	1.047	10.46
P_1 x N_4	76.22	47.67	33.28	116.2	8.1	20.47	1.138	11.38
P_2 x N_1	70.11	47.44	35.02	105.0	7.4	15.89	0.832	8.32
P_2 x N_2	74.44	47.00	32.65	110.5	7.0	17.98	0.896	8.96
P_2 x N_3	76.67	46.89	34.93	108.9	8.4	20.91	0.941	9.40
P_2 x N_4	78.88	46.55	35.54	116.1	8.6	22.37	1.139	11.38
P_3 x N_1	73.33	46.11	36.74	119.8	7.8	21.10	1.164	11.64
P_3 x N_2	76.11	45.55	35.17	123.3	7.8	21.19	1.180	11.79
P_3 x N_3	79.33	45.78	37.58	127.3	8.5	22.48	1.350	13.50
P_3 x N_4	82.11	45.44	36.16	125.3	8.8	26.05	1.425	14.25
P_4 x N_1	78.22	45.33	36.44	120.2	8.9	21.63	1.105	11.05
P_4 x N_2	79.22	46.00	34.38	127.2	9.4	25.22	1.395	13.94
P_4 x N_3	82.77	45.11	37.17	129.2	10.0	27.77	1.523	15.23
P_4 x N_4	86.33	44.88	40.06	135.1	10.8	30.67	1.788	17.88
S.Em±	0.396	0.241	0.635	1.530	0.264	0.853	0.039	0.398
CD (0.05P)	1.176	0.716	1.886	4.545	0.784	2.534	0.116	1.182
CV(%)	1.9	1.1	3.1	2.2	5.4	6.7	5.8	5.8

Table 2: Effect of nutrient management and seed priming on seed quality of proso millet *cv.* TNAU-145

Treatment	Germination (%)	1000 seed weight (g)	Vigour Index
Nutrient management			
N_1	78.94	5.579	1483
N_2	79.86	5.579	1502
N_3	80.99	5.648	1517
N_4	82.41	5.891	1586
S.Em±	0.376	0.116	29.88
CD(0.05P)	1.117	0.345	88.768
Priming			
P_1	78.61	5.628	1419
P_2	79.30	5.678	1453
P_3	81.25	5.647	1589
P_4	83.05	5.743	1627
S.Em±	0.591	0.045	21.83
CD(0.05P)	1.756	0.134	64.853
Interaction (N x P)			
P_1 x N_1	75.66	5.510	1327
P_1 x N_2	79.11	5.617	1493
P_1 x N_3	79.67	5.480	1581
P_1 x N_4	81.33	5.710	1533
P_2 x N_1	79.00	5.560	1448
P_2 x N_2	77.55	5.510	1423
P_2 x N_3	80.22	5.490	1577
P_2 x N_4	82.66	5.757	1561
P_3 x N_1	79.89	5.613	1413
P_3 x N_2	79.66	5.703	1394
P_3 x N_3	81.00	5.723	1555
P_3 x N_4	83.44	5.550	1708
P_4 x N_1	79.89	5.827	1491
P_4 x N_2	80.89	5.883	1503
P_4 x N_3	84.11	5.897	1646
P_4 x N_4	84.77	5.957	1706
S.Em±	1.631	0.103	35.61
CD (0.05P)	4.845	0.306	105.79
CV(%)	3.5	3.1	4.0

Nutrient management: N_1: No fertilizer; N_2: 125 kg Neem + 1250 kg Vermicompost per ha; N_3: 40 kg Urea + 20 kg SSP and 10 kg MOP per ha + Top dressing urea at 3-4 weeks after transplanting + 2% Borax: N_4: 125 kg Neem + 1250 kg Vermicompost per ha + 40 kg Urea + 20 kg SSP and 10 kg MOP per ha + Top dressing urea at 3-4 weeks after transplanting + 2% Borax.

Priming treatments: P_1: Control; P_2: Hydro-priming for 6h; P_3: Seed priming with 2% KH_2PO_4 for 6h; P_4: Seed priming with 20% liquid *Pseudomonas fluorescence*

Conclusion

The direct sowing of proso millet with fertilizer dose 125 kg neem + 1250 kg vermi-compost per ha + 50 kg Urea + 50 kg SSP and 50 kg MOP per ha + top dressing urea at 3-4 weeks after transplanting + 2% borax spray at flowering stage enhanced the seed yield and quality in proso millet *cv.* TNAU-145. The resultant increase in the yield of N_4 (integrated application of organic and inorganic fertilizers) was to the extent of 44.76 per cent against control (N_1). The synergy of integrated application of organic and inorganic sources of fertilizers increased fertilizer efficiency and potential yield of proso millet. Hence, the integrated application of organic and inorganic fertilizers may be practiced to obtain better productivity and quality in proso millet. Seed priming with 20% liquid *Pseudomonas fluorescence* enhanced the yield of proso millet *cv.* TNAU-145 by 39.0 per cent. Besides, yield, priming enhanced the resultant vigour of the seeds. Hence, priming could be adopted to obtain uniform emergence, potential yield and quality in proso millet crop. The combination of priming and fertilizer application enhanced the seed yield and quality of proso millet to a greater extent. Hence, combining seed priming and integrated fertilizer application offers the best growth and yield in proso millet.

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