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Effect of row spacing and potassium management on the growth and yield attributes of Barnyard millet (*Echinochloa frumentacea* L.) under irrigated conditions

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Abstract
Nowadays, the consumption of barnyard millet a nutri-rich cereal has risen drastically. This has led to the development of newer varieties to produce more tillers and yield. However, the productivity of these varieties can possibly be enhanced through optimizing the row spacing for higher yields and also including potassium as a recommended fertilizer. Therefore, a study was conducted during the summer season of 2022 at Department of Agronomy, Agricultural College and Research Institute, Madurai, Tamil Nadu to study the effect of row spacing and potassium management on the growth and yield attributes of Barnyard millet (*cv.* MDU 1) under irrigated conditions. The experiment was laid out in split plot design and replicated thrice with main plot consisted of row spacing (22.5, 25.0 and 30.0) with a plant to plant spacing of 10cm. The subplot consisted of Potassium management (10, 20, 30kg/ha and enriched FYM @ 750kg ha^{-1} + K releasing bacteria, recommended dose of fertilizer (RDF) + Enriched organo-mineral compost @ 750kg ha^{-1} along with control). Results revealed that, sowing seeds at the spacing of 22.5 × 10cm recorded significantly higher yield attributes viz., number of productive tillers m^{-2} (92.0), 1000 grain weight (3.24g). Secondarily, application of RDF along with 10kg of potassium recorded better growth and yield attributes viz., number of tillers m^{-2} (147), number of productive tillers m^{-2} (93.4), number of grains $earhead^{-1}$ (1734), Length of earhead (19.4cm), Weight of earhead (9.12 g) of barnyard millet. Based on this, cultivating barnyard millet at a closer spacing of 22.5 × 10cm along with inclusion of potassium with a recommended dose of fertilizer @ 40:20:10 kg ha^{-1} can significantly increase the overall productivity under irrigated conditions.

Keywords: Barnyard millet, row spacing, potassium application, organo mineral compost, K releasing bacteria

Introduction
Barnyard millet (*Echinochloa frumentacea* L.) belongs to the family Poaceae originated from Eurasia is cultivated and grown primarily for forage. It is the fourth most produced millet, providing food security to many poor people across the world among which India is the biggest producer of barnyard millet, both in terms of area (1.46 lakh ha^{-1}) and production (1.47 lakh tonnes), with an average productivity of 1034 kg ha^{-1} (IIMR, 2018) [9]. Barnyard Millet is cultivated in most of the southern and central states in India is mainly cultivated in Odisha, Maharashtra, Gujarat, Madhya Pradesh, Tamil Nadu and Bihar besides hills of Uttar Pradesh (Chandra *et al*., 2021) [3].
Barnyard millet is a short duration crop that can grow in adverse environmental conditions with almost no input and can withstand various biotic and abiotic stresses. It is especially grown wherever annual rainfall is below 350 mm, whereas no other cereal crop can grow under such moisture stress (Habiyaremye *et al.*, 2017) [7]. In countries like India, Japan and China, Barnyard millet is often used as a substitute for rice when the paddy crop fails (Sood *et al.*, 2015) [23].
Nowadays the demand for barnyard millet has risen drastically due to its nutritional quality and high dietary fibre, it helps in preventing diabetes and cardio vascular disease with regular intake. The nutrient content of barnyard millet is protein (11.8g), fibre (10.1g), minerals (4.4g), iron (15.2mg), calcium (11mg) and crude fibre (9.8%). It also consists of 16.6%of amino acid (Leucine) which is twice that is present in rice (Prakash and Vanniarajan, 2013) [18].
Barnyard millet is a potential crop for the bio-fortification of micronutrients because the grains

are rich in micronutrients (Fe and Zn), (Renganathan *et al*., 2020) [22]. All these features make barnyard millet an ideal supplementary crop for subsistence farmers and also as an alternate crop during the failure of monsoons in rice/major crop cultivating areas (Gupta *et al*., 2009) [6].

The productivity of barnyard millet is low. Because, as barnyard millet is mostly grown under rain fed and hilly areas on poor shallow and marginal soils. Secondarily, the seeds are often broadcasted and it is cultivated under unfertilized and unweeded condition.

Therefore, a suitable sowing / planting method with balanced supply of nutrients and proper weed management practices are essential for obtaining higher yield. Among these, the appropriate planting method and fertility management have a significant impact on barnyard millet productivity (Michaelraj and Shanmugam, 2013) [15]. To obtain satisfactory yield, stand establishment is important and it is dependent on sowing of quality seeds at optimum spacing and uniform germination (Maitra *et al*., 2020) [14].

Through optimum crop geometry the competition among the plants can be reduced and through optimum plant population at the time of harvest can influence the yield output. Through proper spacing plant can gain sufficient sunlight, water and nutrition from soil, which can influence healthy yield and yield attributes (Anandha Krishnaveni *et al*., 2020) [1].

Barnyard millet is cultivated in low fertile dry land soils and is merely supplemented with N and P, ignoring the requirement of K due to soil, natively rich in potassium. However, long-term intense cropping without its application resulted in low to medium status and decreased potassium supply to plants and consequently reduced the crop yields. Potassium is a necessary nutrient for the activation of more than 80 enzymes throughout the plant (Sundaresh and Basavraja, 2017) [26]. It improves grain filling, grain weight, straw strength, disease resistance and the plant's ability to handle stress.

Moreover, K increases the water use efficiency and transforms sugar into starch in the grain filling process (Srinivasarao *et al*., 2013) [25]. Higher yield of barnyard millet can be realized with optimum plant density and proportionate use of three primary nutrients namely, N, P and K to provide balanced fertilization to crops (Maitra *et al*., 2020) [14].

Considering the above facts an attempt has been made to undertake this research with the objective to study the effect of row spacing and potassium management on growth and yield of barnyard millet under irrigated condition.

Materials and Methods

The field experiment was conducted in Field No. 20 at A Block Farm, Department of Agronomy, Agricultural College and Research Institute, Madurai, Tamil Nadu during summer season (Feb-June) of 2022. The farm is located in the Southern Agro-climatic Zone of Tamil Nadu at 9º 96´ N and 78º 20´ E and 147 m above sea-level. During the crop period average minimum and maximum temperature ranged between 21.2ºC to 32.1ºC with RH of 69.4% and rainfall of 703.4 mm was received in 32 rainy days. The soil is sandy clay loam with 32.5%, 30.6%, 11.1% and 25.8% respectively of sand, fine sand, silt and clay respectively.

The experiment was designed in split plot design and replicated thrice with main plot consisting of row spacing [$RS_{22.5}$: 22.5 × 10cm, RS_{25}: 25.0 × 10cm, RS_{30}: 30.0 × 10cm] and subplot consisted of Potassium management with recommended dose of fertilizer (RDF) [K_{Con}: RDF (40:20:0 NPK kg ha^{-1}), K_{10}: RDF + 10 kg K_2O ha^{-1}, K_{20}: RDF + 20 kg K_2O ha^{-1}, K_{30}: RDF + 30 kg K_2O ha^{-1}, K_{eF+KRB}: RDF + Enriched FYM @ 750 kg ha^{-1} + Potassium releasing bacteria (KRB) @ 50 mL per acre seeds K_{OM}: RDF + Enriched organo mineral compost @ 750 kg ha^{-1}].

The crop was sown during 3rd week of February, 2022 and the nutrients N, P and K were applied to each plot in the form of urea, single super phosphate (SSP) and muriatic of potash (MOP) according to the treatments assigned. Entire dose of phosphorus were applied as basal where nitrogen and potassium was applied in two equal splits, 50% each at basal and 45th days after sowing (DAS). The first crop harvested was initiated in the first fortnight of June, 2022. The recommended package of practices were adopted as per the Crop Production Guide, 2020 from the Tamil Nadu Agricultural University, Coimbatore. Various observation on the growth characters, yield parameters, and yield was recorded.

The data recorded were statistically analysed for split plot design using the Analysis of Variance (ANOVA) at 5% level, if the treatment difference was determined to be significant (‘F’ test). Non-significant treatment differences were denoted by ‘NS’.

Results and Discussion

Effect of crop geometry and potassium on growth parameters of barnyard millet

Row spacing and potassium had a remarkable effect on the growth of barnyard millet. Among the various crop geometries tried, adoption of the spacing of 22.5 × 10 cm recorded significantly more (145) number of tillers per m^2 which was on par with the spacing of 25 × 10 cm (134) respectively (Table 1). The more number of tillers m^{-2} is mainly due to better aeration at optimum spacing resulting in healthier plant growth with more tillers. These results are concordant with the findings of Korir (2019) [12]. The lowest number of tillers m^{-2} (93.7) were recorded under the spacing of 30 × 10 cm.

With respect to potassium, application of RDF + 10 kg K_2O ha^{-1} recorded significantly maximum number of tillers m^{-2} of 147 followed by RDF + Enriched oregano mineral compost @ 750 kg ha^{-1} with 132 tillers m^{-2}. The possible reason might be due to role of K in development of strong cell walls which led to stiffer straw and profuse tillering. These results are in similarity with the findings of Latha and Singh (2003); Kacha *et al.* (2011) and Chaudhary *et al.* (2014) [13, 11, 5]. The minimum number of tillers m^{-2} (105) were recorded in RDF + 30 kg K_2O ha^{-1}.

Among the interaction effects, spacing of 22.5 × 10 cm and RDF + 10 kg K_2O ha^{-1} recorded significantly higher number of tillers m^{-2} (184). The reason behind this might be due to higher availability of the nutrients and solar radiation (Hussainy and Vaidyanathan, 2019) [8] that resulted in better growth and development of the auxiliary buds that lead to higher number of tillers m^{-2}. This was in agreement with Prakasha *et al.* (2018) [19].

Effect of crop geometry and potassium on yield attributes of barnyard millet

With regard to the crop geometry, adoption of the spacing of 30 × 10cm recorded significantly maximum yield attributes *viz.*, number of grains (1661 earhead^{-1}), length of earhead

(18.3 cm), (Table 3) followed by the spacing of 25 × 10 cm with number of grains earhead^{-1} (1399). The increase in plant spacing might be due to the effective utilization of available resources such as sunlight, water and nutrient for the plant growth which further increase in the photosynthetic rate and enhancement of yield attributing characters (Pramanik and Bera, 2013) [20]. The synthesized photosynthates might be Trans located to the growing panicles which result in the grain filling and increase in the weight of the panicles (Pradeep Kumar, 2018) [17]. However, maximum number of productive tillers m^{-2} (92) and 1000 grain weight (3.24 g) was attained with plant spacing of 22.5 × 10cm (Table 2). The lower number of productive tillers m^{-2} (44.2) was observed under the spacing of 30 × 10 cm. This is mainly due to higher photosynthetic area available with closer spacing (22.5 × 10cm) which might increase the number of productive tillers per m^2. These conclusions are in accordance with Patra and Nayak (2001) [16].

Considering the potassium levels, application of RDF + 10 kg K_2O ha^{-1} produced higher yield attributes *viz.*, number of productive tillers m^{-2} (93.4), number of grains earhead^{-1} (1734), length of earhead (19.4 cm) and weight of earhead (9.12 g) of Barnyard millet over the other potassium levels and it was followed by the application of RDF + Enriched organo mineral compost @ 750 kg ha^{-1} with 1589 number of grains earhead^{-1} and 8.74 g of earhead weight. The lower values of the yield attributes were recorded under RDF + 30 kg K_2O ha^{-1}. Potassium involved in the various metabolic activities such as translocation of photosynthates, transforming the sugar into starch in the grain filling process (Srinivasarao *et al.*, 2013) [25].

The interaction effect between crop geometry and potassium were found significant for number of productive tillers m^{-2}, number of grains earhead^{-1}, length of earhead, Weight of earhead. The combined effect of the adoption of spacing of 22.5 × 10cm and RDF + 10 kg K_2O ha^{-1} recorded the significant interaction with regard to number of productive tillers m^{-2} (126) whereas the spacing of 30 × 10cm and RDF + 10kg K_2O ha^{-1} recorded the significant interaction with regard to number of grains earhead^{-1} (2069), length of earhead (23.3cm), weight of earhead (13.2cm) of barnyard millet. Adoption of optimum spacing and fertilization with the essential nutrients helps in better growth and photosynthesis, which further increase the grain yield of crop.

Effect of crop geometry and potassium on estimated grain yield of barnyard millet

Yield of barnyard millet significantly varies with the different plant geometries. Adoption of the plant spacing of 22.5 × 10cm tend to produce significantly higher estimated grain yield (3754 kg ha^{-1}) and the spacing adoption of 25 × 10cm ranks next with 3478 kg ha^{-1}of grain yield, respectively. The increase in grain yield is resultant of the adoption of optimum spacing which leads to the optimum plant population resulting in the higher grain yield. The adoption of optimum spacing reduces the competition among the crops which further increase the effective utilization of available resources and increases the productive potential of crops (Prakasha *et al.*, 2018) [19]. Lower estimated grain yield (2352 kg ha^{-1}) will be produced under the spacing of 30 × 10cm due to lesser plant population when compared to other crop geometries studied.

Among the different potassium levels, application of RDF + 10kg K_2O ha^{-1} produce significantly maximized the estimated grain (3768 kg ha^{-1}) yield followed by application of RDF + Enriched organo mineral compost @ 750 kg ha^{-1} with 3392kg ha^{-1} of estimated grain yield. Minimum estimated grain yield (2676kg ha^{-1}) was observed under RDF + 30kg K_2O ha^{-1}. Potassium application might have helped to produce large amount of starch due to K-mediated carbohydrate metabolism, which performed efficient translocation of photo-assimilates to the developing ear heads which directly helped in increasing the grain yield and straw yield. Similar findings were also reported by Javeed *et al.* (2017) and Charate *et al.* (2018) [10, 4].

The combined effect of the adoption of spacing of 22.5 × 10 cm and RDF + 10 kg K_2O ha^{-1} recorded significantly higher number of productive tillers m^{-2} (126) (table 2) and estimated grain yield (4739kg ha^{-1}), (Table 4). Adoption of optimum spacing and fertilization with essential nutrients helps in better growth and photosynthesis, which would further aid in production of more number of productive tillers m^{-2} ultimately attaining higher grain yield in barnyard millet. Similar result was obtained by Aravinth *et al.* (2019) [2] in finger millet. This showed that crop needs optimum spacing and nutrition for growth and development. Increased grain yields may be due to the cumulative effect of increased photosynthate translocation to the sink, resulting in higher levels of yield components. The results are in line with the findings of Rao *et al.* (2004) [21].

Table 1: Effect of row spacing and potassium on growth parameters of barnyard millet at maturity stage

Row Spacing - K Level	No. of tillers m^{-2}			
	$RS_{22.5}$	**RS_{25}**	**RS_{30}**	**Mean**
K_{10}	184	157	99.7	147
K_{20}	155	139	88.0	127
K_{30}	113	115	88.6	105
K_{eF+KRB}	124	133	98.8	119
K_{OM}	157	127	111	132
K_{Con}	137	133	76.1	115
Mean	145	134	93.7	
	RS	K	RS × K	K × RS
S.Ed	6.61	3.57	7.76	4.46
CD (P=0.05)	18.3	7.37	20.0	9.12

Table 2: Effect of row spacing and potassium on number of productive tillers m^{-2} and 1000 grain weight (g) of barnyard millet at maturity stage

Row Spacing - K Level	Number of productive tillers m^{-2}				1000 grain weight (g)			
	$RS_{22.5}$	**RS_{25}**	**RS_{30}**	**Mean**	**$RS_{22.5}$**	**RS_{25}**	**RS_{30}**	**Mean**
K_{10}	126	106	48.1	93.4	3.31	3.20	3.24	3.25
K_{20}	97.2	96.8	38.6	77.5	3.26	3.15	3.26	3.22
K_{30}	70.6	64.8	44.7	60.0	3.12	3.22	3.28	3.21
K_{eF+KRB}	72.7	78.9	46.4	66.0	3.24	3.29	3.24	3.26
K_{OM}	97.1	76.8	49.9	74.6	3.19	3.27	3.19	3.22
K_{Con}	88.6	85.1	37.3	70.3	3.32	3.16	3.19	3.22
Mean	92.0	84.7	44.2		3.24	3.22	3.23	
	RS	K	RS × K	K × RS	RS	K	RS × K	K × RS
S.Ed	6.32	2.09	7.13	3.62	0.010	0.027	0.044	0.047
CD (*P*=0.05)	17.54	4.27	18.67	7.39	NS	NS	NS	NS

Table 3: Effect of row spacing and potassium on number of grains earhead^{-1}, length of earhead (cm), weight of earhead (g) of barnyard millet at maturity stage

Row Spacing - K Level	Number of grains earhead^{-1}				Length of earhead (cm)				Weight of earhead (g)			
	$RS_{22.5}$	RS_{25}	RS_{30}	Mean	$RS_{22.5}$	RS_{25}	RS_{30}	Mean	$RS_{22.5}$	RS_{25}	RS_{30}	Mean
K_{10}	1479	1653	2069	1734	16.4	18.5	23.3	19.4	9.12	11.4	13.2	9.12
K_{20}	1266	1598	1749	1538	15.2	16.9	17.7	16.6	8.34	10.5	11.3	8.34
K_{30}	960.5	1059	1458	1159	12.9	15.2	20.1	16.1	7.25	8.75	9.65	7.25
K_{eF+KRB}	1271	1458	1539	1423	13.9	12.3	17.5	14.6	7.56	8.53	11.4	7.56
K_{OM}	1419	1575	1773	1589	14.1	14.9	16.1	15.0	8.74	9.82	9.81	8.74
K_{Con}	860.5	1049	1380	1096	14.9	17	15.2	15.7	8.32	9.64	8.82	8.32
Mean	1209	1399	1661		14.6	15.8	18.3		9.12	11.4	13.2	9.12
	RS	K	RS × K	K × RS	RS	K	RS × K	K × RS	RS	K	RS × K	K × RS
S.Ed	55.62	36.63	80.30	63.45	0.77	0.38	0.95	0.65	0.45	0.28	0.59	0.35
CD (P=0.05)	154.4	74.81	192.3	129.5	2.14	0.77	2.47	1.33	1.26	0.58	1.53	0.71

Table 4: Effect of row spacing and potassium on estimated yield (kg ha^{-1}) of barnyard millet

Row Spacing - K Level	Estimated yield (kg ha^{-1})			
	$RS_{22.5}$	RS_{25}	RS_{30}	Mean
K_{10}	4739	4061	2504	3768
K_{20}	4005	3659	2199	3288
K_{30}	2910	2901	2217	2676
K_{eF+KRB}	3249	3386	2400	3012
K_{OM}	4013	3339	2823	3392
K_{Con}	3608	3524	1970	3034
Mean	3754	3478	2352	
	RS	K	RS × K	K × RS
S.Ed	181.90	65.91	209.64	114.15
CD (P=0.05)	505.04	134.60	544.01	233.13

Conclusion
From the above study, it could be concluded that the spacing of 22.5 × 10 cm along with application of 10 kg of K per hectare along with Nitrogen and Phosphorus @ 40 and 20 kg ha^{-1} can be recommended to obtain maximum yield in barnyard millet under irrigated conditions. Further, a study on the application of micronutrients may be focused to further increase the productivity of minor millets especially barnyard millet.

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References

1. Anandha Krishnaveni S, Avudaithai S. Effect of Crop Geometry and Nutrient Management in Barnyard Millet under Sodic Soil Condition. Int. J Curr. Microbiol. App. Sci. 2020;9(06):276-280.
2. Aravinth K, Senthil Kumar N, Joseph M, Paramasivan M. Effect of plant geometry and graded NPK levels on growth and yield of transplanted finger millet (*Eleusine coracana* L.) International Journal of Agriculture Sciences. 2019;11(10):8491-8493.
3. Chandra AK, Chandora R, Sood S, Malhotra N. Global production, demand, and supply. In Millets and Pseudo Cereals. Woodhead Publishing, 2021, 7-18.
4. Charate S, Thimmegowda M, Rao GE, Ramachandrappa B, Sathish A. Effect of nitrogen and potassium levels on growth and yield of little millet (*Panicum Sumatrense*) under dry land alfisols of southern Karnataka. International Journal of Pure and Applied Biosciences. 2018;6(6):918-923.
5. Chaudhary N, Khafi H, Raj A, Yadav V, Yadav P. Effect of nutrients (K and S) on growth, yield and economics of summer pearl millet [*Pennisetum Glaucoma* (L.)]. International Journal of Forestry and Crop Improvement. 2014;5(1):9-12.
6. Gupta A, Mahajan V, Kumar M, Gupta H. Biodiversity in the barnyard millet (*Echinochloa frumentacea* Link. Poaceae) germplasm in India. Genet. Resour. Crop Evol. 2009;56:883-889.
7. Habiyaremye C, Matanguihan JB, D'AlpoimGuedes J, Ganjyal GM, Whiteman MR, Kidwell KK, *et al.* Proso millet *(Panicum Miliaceum* L.) and its potential for cultivation in the Pacific Northwest, US: a review. Frontiers in plant science. 2017;7:1961.
8. Hussainy SAH. Vaidyanathan R. Influence of groundnut (Arachis hypogaea) based intercropping under different levels of irrigation on the performance of intercrops. Journal of Pharmacognosy and Phytochemistry. 2019;8(2):682-685.
9. IIMR. Annual Report 2017-18. Hyderabad: Indian Institute of Millets Research, 2018.
10. Javeed, Meenakshi Gupta, Vikas Gupta. Effect of graded levels of N, P & K on growth, yield and quality of fine rice cultivar (*Oryza sativa* L.) under subtropical conditions. Scientific Society of Advanced Research and Social Change International Journal of Management. 2017;3(1):1-8.
11. Kacha DJ, Khafi HR, Mehta AC, Shekh MA, Jadav RP. Effect of potassium and zinc on yield and quality of rabi pearl millet (*Pennisetum glaucoma*). Crop Research. 2011;41(1, 2, 3):31-3.
12. Korir AK. Effects of fertilization and spacing on growth and grain yields of finger millet (*Eleusine coracana* L.) in Ainamoi, Kericho County. PhD diss., KeMU, 2019.
13. Latha KR, Durai Singh R. Effect of cropping systems and fertilizer levels on the nutrient uptake and yield by sorghum in rainfed vertisols. Indian Journal of Agricultural Research. 2003;37(3):209-213.
14. Maitra Sagar, Panda Pritam, Panda Shravan Kumar, Behera Dibyajyoti, Shankar Tanmoy, Nanda S. Relevance of Barnyard Millet (*Echinochloa frumentacea* L.) Cultivation and Agronomic Management for Production Sustainability, 2020.
15. Michaelraj PSJ, Shanmugam A. A study on millets based cultivation and consumption in India. Intl. J of Marketing, Financial Services and Mgt. Res. 2013;2(4):49-58.
16. Patra AK, Nayak BC. Effect of spacing on rice (*Oryza*

sativa) varieties of various duration under irrigated condition. Indian Journal of Agronomy. 2001;46(3):449-452.
17. Pradeep Kumar BK. Optimization of spacing and nutrients in seed production of foxtail millet (*Setaria Italica* L.). M.Sc. (Agri.) Thesis. University of Agricultural Sciences, Bengaluru, 2018.
18. Prakash R, Vanniarajan C. Genetic variability for panicle characters in indigenous and exotic barnyard millet (*Echinochloafrumentacea* (Roxb.) link) germplasm over environment. Vegetos. 2013;26(2):297-306.
19. Prakasha G, Kalyana Murthy K, Prathima A, Rohani N. Effect of spacing and nutrient levels on growth attributes and yield of finger millet (*Eleusine Coracana* L.) cultivated under Guni planting method in red sandy loamy soil of Karnataka, India. International Journal of Current Microbiology and Applied Sciences. 2018;7(05):1337-1343.
20. Pramanik K, Bera AK. Effect of seedling age and nitrogen fertilizer on growth, chlorophyll content, yield and economics of hybrid rice (*Oryza sativa* L.). International Journal of Agronomy and Plant Production. 2013;4(5):3489-99.
21. Rao K, Surekha K, Kundu D, Prasad A. Nutrient management to sustain productivity targets of irrigated rice. International Symposium on Rice: From Green Revolution to Gene Revolution, 2004, 416-417.
22. Renganathan VG, Vanniarajan C, Karthikeyan A, Ramalingam J. Barnyard millet for food and nutritional security: current status and future research direction. Frontiers in genetics. 2020;11:500.
23. Sood S, Khulbe RK, Gupta AK, Agrawal PK, Upadhyaya HD, Bhatt JC. Barnyard millet–a potential food and feed crop of future. Plant Breeding. 2015;134(2):135-147.
24. Srinivasarao C, Kundu S, Ramachandrappa BK, Reddy S, Lal R, Venkateswarlu B, *et al*. Potassium release characteristics, potassium balance, and fingermillet (*Eleusine Coracana* G.) yield sustainability in a 27-year long experiment on an Alfisol in the semi-arid tropical India. Plant and soil. 2014;374(1):315-30.
25. Srinivasarao CH, Sumanata Kundu BK, Ramachandrappa Sharanbhoopal Reddy, Rattan Lal B, Venkateswarlu KL, Sahrawat R, *et al.* Potassium release characteristics, potassium balance and finger millet yield sustainability in a 27 year long experiment on an alfisol in the semi arid tropical India, 2013.
26. Sundaresh R, Basavaraja PK. Influence of Different Levels of Phosphorus and Potassium on Growth, Yield Attributes and Economics of Finger Millet in Low Phosphorus and Potassium Soils of Eastern Dry Zone of Karnataka, India. International Journal of Current Microbiology and Applied Sciences. 2017;6(11):3559-66.