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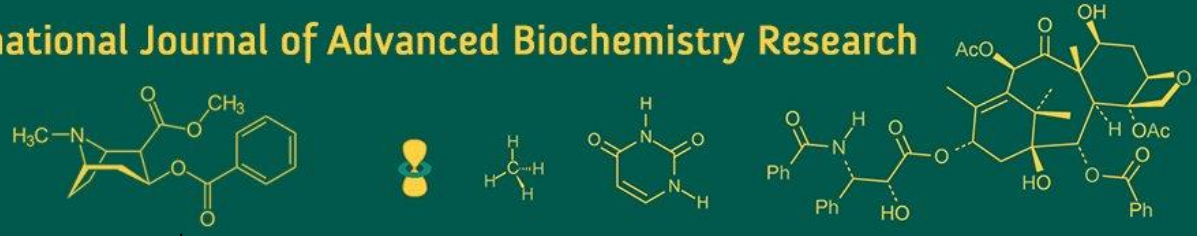

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Effect of different sowing windows and nutrient levels on yield attributes, yield and economics of barnyard millet during *rabi* season

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Abstract
A field experiment was conducted during *rabi* season of 2023-24 on barnyard millet at Agronomy Farm, College of Agriculture, Nagpur (M.S.). The soil of the experimental plot was clayey in texture, slightly alkaline in reaction (pH 7.7), low in available nitrogen (272.20 kg ha^{-1}), medium in available phosphorus (22.66 kg ha^{-1}) and high in available potassium (390.65 kg ha^{-1}). The experiment was laid out in factorial randomized block design (FRBD) with nine treatment combinations of three sowing windows and three fertilizer levels and replicated three times. The treatments consisted of three sowing windows *viz*., D_1- 43rd MW, D_2- 45th MW and D_3- 47th MW, and three nutrient levels *viz*., F_1- 15:15:00, F_2- 20:20:00 and F_3- 25:25:00 kg N:P:K ha^{-1}. The result revealed that among the dates of sowing, number of panicles $hill^{-1}$, length of panicle, panicle weight, grain and straw weight $plant^{-1}$, grain, straw, biological yield and gross monetary returns, net monetary returns and B:C ratio were significantly higher with D_1- 43rd MW sowing and among the nutrient levels, F_3- 25:25:00 kg N:P:K ha^{-1} recorded more number of panicles $hill^{-1}$, length of panicle, panicle weight, grain and straw weight $plant^{-1}$, grain, straw, biological yield and gross monetary returns, net monetary returns and B:C ratio.

Keywords: Barnyard millet, MW, nutrient levels, sowing windows, yield, panicle

Introduction
Barnyard millet is the oldest domesticated small millet. There are two main species of Barnyard millet, one is *Echinochloa esculenta* which is Japanese Barnyard millet or Japanese millet and other is *Echinochloa frumentacea* which is Indian Barnyard millet. The Indian barnyard millet is also known as Billion Dollar Grass. *Echinochloa frumentacea* is the hardest millet and commonly known by several names *viz:* Sanwa and Jhangora (hindi), Shyama (sanskrit), Oodalu (kannada), Kuthiravaali (tamil), Udalu and Kodisama (telgu), Bhagar (marathi), Sama (gujarati), Shamula (bengali) and Swank (punjabi). (Kaur and Sharma, 2020) [2].

Barnyard millet is a multi-reason crop. Nutritionally, it is a decent source of protein, which is profoundly absorbable and is an amazing source of dietary fibre. Carbohydrate present in barnyard millet is low and slowly digestible, which makes the barnyard millet a natural gift for the mankind. In barnyard millet, the significant unsaturated fats are linoleic acid and oleic acid. Consequently, can be suggested for the patients with cardiovascular sickness and diabetes mellitus. Now a day, the interest of consumers is increasing toward the healthy nutrition rich food products. Hence use of barnyard millet should be investigated to produce new products such as puff, cookies, noodles and pasta, fermented products, etc. (Kaur and Sharma, 2020) [2] to tap the potential market.

Barnyard millet (*Echinochloa frumentacea*) is a small millet which is emerging as an important dual-motive crop as feed and fodder. It has specific adaptation properties for degraded land and capacity to tolerate the abiotic strain and grow in extreme climatic conditions. (Kaur and Sharma, 2020) [2]. Small millets are regaining their importance in modern agriculture. Sowing time has an important role in production and productivity of any crop. Crops sown at optimum time has the advantage of being exposed to congenial climate at all growth stages and this, in turn, improves the productivity of crop. (Kiranmai *et al.*, 2021) [3]. Delay in sowing causes early maturity resulting in to drastic reduction in yield as compared to normal sowing which has a longer growth duration that consequently provides

an opportunity to accumulate more biomass (Nandini and Sridhara., 2019) [4].

Similarly, nutrient management is one of the key factors influencing the production of any crop. Proper fulfilment of nutrient requirement of the crop safeguards it against the hidden hunger and contributes forwards realization of potential output of the crop. Barnyard millet is typically grown on poor or low fertile soils without much inputs, under rainfed conditions, hence its average productivity is very low.

Hence, in order to include barnyard millet as a *rabi* crop in the cropping sequence, it is inevitable to assess an optimum time for its sowing during *rabi* season. Similarly, being a small millet crop traditionally it was grown without any nutrient input. In this context, it is worthwhile to assess the response of this crop to added nutrients under given condition.

Methods and Materials

An experiment was conducted at Agronomy Farm, College of Agriculture, Nagpur during *rabi* seasons of 2023-24. The experimental site is located at 20° 10' N latitudes and 79° 19' E longitudes at 321 meters above the mean sea level. The soil of the experimental plot was clayey in texture, slightly alkaline in reaction (pH 7.7), low in available nitrogen (272.20 kg ha^{-1}), medium in available phosphorus (22.66 kg ha^{-1}) and high in available potassium (390.65 kg ha^{-1}). The experiment was laid out in factorial randomized block design (FRBD) with nine treatment combinations of three sowing windows and three fertilizer levels and replicated three times. The treatments consisted of three sowing windows *viz*., D_1- 43rd MW, D_2- 45th MW and D_3- 47th MW, and three nutrient levels *viz*., F_1- 15:15:00, F_2- 20:20:00 and F_3- 25:25:00 kg N:P:K ha^{-1}. Barnyard millet variety (DHBM-93-3) was sown on respective sowing dates by adopting a spacing 30 cm x 10 cm. Full dose of phosphorus along with 50% of nitrogen was applied as basal and remaining 50% nitrogen was applied as top dressing. During the crop growth period (October 28th to March 5th) total rainfall of 38.4 mm in three rainy days, data on growth and yield attributes were recorded from randomly selected five plants from each net plot and the mean value was worked out. Cost of cultivation was calculated and studies on economics were carried out with the help of prevailing market price of barnyard millet. The data was statistically analayzed with standard method outlined for randomized block design (Gomez and Gomez, 1984) [1]. Statistically significance was tested by F-value at 0.05% level of probability and critical difference was worked out wherever the effect was significant.

Results and Discussions

Yield attributes

Effect of sowing windows

It is clearly evident from the data (Table.1) that dates of sowing had significant effect on yield attributes of barnyard millet. Among the date of sowing, crop sown during 43rd MW (D_1) recorded significantly more number of panicles $hill^{-1}$, length of panicle, panicle weight, grain and straw weight $plant^{-1}$ but it was at par with the crop sown during 45th MW (D_2). Late sowing of barnyard millet in *rabi* during 47th MW (D_3) resulted in lowest number of panicles $hill^{-1}$, length of panicle, panicle weight, grain and straw weight $plant^{-1}$.

Early sown crop head experienced prolonged photoperiod that reflected in improved assimilate synthesis and translocation coupled with favorable weather variables that favoured plant height, number of tillers $plant^{-1}$ and yield attributes which in turn favoured a better partitioning of assimilates from source to sink. These findings are in agreement with Nandini and Sridhara (2019) [4], Nigade *et al.* (2021) [5] and Tomar *et al.* (2020) [13].

Effect of nutrient levels

Nutrient levels had a significant impact on the number of panicles $hill^{-1}$, length of panicle, panicle weight, grain and straw weight $plant^{-1}$. Highest number of panicles $hill^{-1}$, length of panicle, panicle weight, grain and straw weight $plant^{-1}$ was recorded with application of 25:25:00 kg N:P:K ha^{-1} (F_3) which was at par with the treatment receiving 20:20:00 kg N:P:K ha^{-1} (F_2). Application of 15:15:00 kg N:P:K ha^{-1} (F_1) produced the least number of panicles $hill^{-1}$, length of panicle, panicle weight, grain and straw weight $plant^{-1}$.

Application of higher dose of fertilizer might have resulted into a higher availability of nutrients to the crop, which might have enhanced the yield attributes *viz.* number of panicles $hill^{-1}$, length of panicle and panicle weight, which might have reflected as an increased grain and straw weight $plant^{-1}$. Similar results were also reported by Anandha Krishnaveni (2018) [7], Pol *et al.* (2019) [6] and Soutade and Raundal (2022) [10].

Table 1: Yield attributes of barnyard millet as influenced by sowing windows and nutrient levels

Treatment	Mean number of panicles $hill^{-1}$	Length of panicle (cm)	Panicle weight (g)	Grain Weight $plant^{-1}$ (g)	Straw Weight $plant^{-1}$ (g)
A. Sowing Windows					
D_1 - 43rd MW	4.64	16.04	2.73	4.20	10.42
D_2 - 45th MW	4.44	15.04	2.50	3.97	10.03
D_3 - 47th MW	3.96	14.39	2.22	3.86	9.14
S.E. (m) ±	0.16	0.34	0.09	0.08	0.20
C.D. at 5%	0.47	1.03	0.27	0.24	0.58
B. Nutrient Levels (kg N: P: K ha^{-1})					
F_1 - 15:15:00	3.78	13.18	2.26	3.78	9.19
F_2 - 20:20:00	4.40	15.66	2.49	4.06	9.97
F_3 - 25:25:00	4.85	16.64	2.70	4.20	10.44
S.E. (m) ±	0.16	0.34	0.09	0.08	0.20
C.D. at 5%	0.47	1.03	0.27	0.24	0.58
C. Interaction (D x F)					
S.E. (m) ±	0.27	0.59	0.16	0.14	0.34
C.D. at 5%	NS	NS	NS	NS	NS
GM	4.35	15.16	2.48	4.01	9.87

Yield

Effect of sowing windows

Sowing of barnyard millet during 43rd MW (D_1) produced significantly highest grain, straw and biological yield which was at par with grain, straw and biological yield obtained from crop sown during 45th MW (D_2). Late sown crop produced significantly lower grain, straw and biological yield ha^{-1}. However highest harvest index was recorded by crop sown during 47th MW, however crop sown during 45th MW recorded the lowest harvest index.

Early sown (43rd MW) crop during *rabi* might have received favorable atmospheric conditions essential for potential growth of the crop obtained in terms of increased plant height, number of tillers hill^{-1} and dry matter accumulation plant^{-1}. As a result, the yield attributing factors *viz.* number of tillers hill^{-1}, length of panicle and panicle weight might have also improved. This could be the reason for higher grain, straw and biological yield with early sowing compared to late sowing. Similar results were also reported by Saini *et al.* (2018) [9], Nandini and Sridhara (2019) [4], Nigade *et al.* (2021) [5] and Swati *et al.* (2020) [11].

Table 2: Yield and economics of barnyard millet as influenced by sowing windows and nutrient levels

Treatment	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index	Gross monetary returns (Rs. ha^{-1})	Net monetary returns (Rs. ha^{-1})	B:C ratio
A. Sowing Windows							
D_1- 43rd MW	1360	3364	4724	28.78	84958	61833	3.68
D_2 - 45th MW	1267	3204	4471	28.33	79253	56178	3.43
D_3 - 47th MW	1156	2702	3858	29.96	72063	48988	3.12
S.E. (m) ±	38	84	112	-	2352	2352	-
C.D. at 5%	115	251	335	-	7050	7050	-
B. Nutrient Levels (kg N: P: K ha^{-1})							
F_1 - 15:15:00	1154	2790	3944	29.25	72027	49386	3.18
F_2 - 20:20:00	1288	3144	4432	29.06	80446	57371	3.44
F_3 - 25:25:00	1341	3336	4677	28.67	83802	60292	3.56
S.E. (m) ±	38	84	112	-	2352	2352	-
C.D. at 5%	115	251	335	-	7050	7050	-
C. Interaction (D x F)							
S.E. (m) ±	66	145	193	-	4073	4073	-
C.D. at 5%	NS	NS	NS	-	NS	NS	-
GM	1261	3090	4351	28.98	78758	55683	3.41

Effect of nutrient levels

From the data it is observed that there was an improvement in the yield with an increase in nutrient level. Application of 25:25:00 kg N:P:K ha^{-1} (F_3) recorded highest grain, straw and biological yield, which was at par with application of 20:20:00 kg N:P:K ha^{-1} (F_2). Application of a lower dose of 15:15:00 kg N:P:K ha^{-1} resulted in significantly lower grain, straw and biological yield ha^{-1}. However, highest harvest index was recorded with application of 15:15:00 kg N:P:K ha^{-1} (F_3), however application of 25:25:00 kg N:P:K ha^{-1} recorded the lowest harvest index.

The increase in grain, straw and biological yields with enhanced fertilizer application could primarily be attributed to improved nutrient availability and uptake, which subsequently might have enhanced the metabolic efficiency and overall plant productivity. The enhanced soil nutrient status might have supported for better vegetative growth and more effective photosynthesis as well as enhanced reproductive efficiency. Similar results were also reported by Anandha Krishnaveni (2018) [7], Pol *et al.* (2019) [6], Thakur *et al.* (2019), Soutade and Raundal (2022) [10] and Sachin *et al.* (2023) [8].

Economics

Effect of sowing windows

Significantly highest gross monetary returns, net monetary returns and B:C ratio was recorded when crop was sown during 43rd MW. However, it was at par with the gross monetary returns, net monetary returns and B:C ratio obtained in the crop sown during 45th MW. Increase in gross monetary returns, net monetary returns and B:C ratio was due to significant increase in the economic yield of barnyard millet.

Effect of nutrient levels

Data pertaining to economics of barnyard millet showed that gross monetary returns, net monetary returns and B:C ratio were higher in response to more fertilizer application. Assessment of treatments in terms of economic traits revealed that the gross monetary returns, net monetary returns and B:C ratio differed due to different nutrient levels. Among the different nutrient levels, application of 25:25:00 kg N:P:K ha^{-1} (F_1) recorded significantly highest gross monetary returns, net monetary returns and B:C ratio, which was at par with gross monetary returns, net monetary returns and B:C ratio obtained with application of 20:20:00 kg N:P:K ha^{-1} (F_2). Application of 15:15:00 kg N:P:K ha^{-1} (F_3) generated significantly lower gross monetary returns, net monetary returns and B:C ratio. Highest gross monetary returns, net monetary returns and B:C ratio recorded in late sown crop could be attributed to the increased grain yield obtained in the treatment.

Interaction effect

Yield attributes, yield and economics were not significantly influenced by the interaction effect of sowing windows and nutrient levels (Table 1 and 2).

Conclusion

Crop sown during 43rd MW resulted in higher values for yield attributes (number of panicles hill^{-1}, length of panicle, panicle weight, grain and straw weight plant^{-1}) and grain, straw and biological yield of barnyard millet and highest gross monetary returns, net monetary returns and benefit: cost ratio and among different nutrient levels, application of 25:25:00 kg N:P:K ha^{-1} recorded highest yield attributes (number of panicles hill^{-1}, length of panicle, panicle weight,

grain and straw weight plant^{-1}) and grain, straw and biological yield gross monetary returns, net monetary returns and benefit: cost ratio in barnyard millet during *rabi*.

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