# Title. Harmonizing sowing dates with onset of rains to guarantee nutri-millets grain yield and quality under rain dependent farming

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***Abstract***

*Nutri-millets offer copious micronutrients like vitamins, beta-carotene etc. In this present day, all the millets are amazingly superior and are therefore, the result for the malnutrition and obesity that affects a vast majority of the Indian population. They have numerous beneficial properties like drought resistant, good yielding in areas where water is limited and they possess good nutritive values. The prospective water scarcity in semi-arid regions disturbs both normal as well as managed environments, which limits the cultivation of crops, fodder, and other plants. The issues faced by the rain-dependent farming of these semi-arid regions are primarily the unpredictability of the monsoon. Probability analysis of rainfall events are believed to contribute in deciding sowing dates for the current season and for successful crop production in semi-arid environments. The present study was carried out in semi-arid condition to quantify the performance of nutri-millets in the rain dependent farming. The experiment was laid out under factorial randomized block design with 3 replications. The treatments comprises of crop factor viz., Sorghum [Sorghum bicolor (L.) Moench] (C1) and, little millet [Panicum sumatrense Roth ex Roem. & Schult] (C2) and sowing window factor viz., sowing based farmer's practice (M1) i.e. on 31st standard meteorological week (SMW); Sowing at 33$^{rd}$ SMW based on 50% rainfall probability (M2); Sowing at 38$^{th}$ SMW based on 75% rainfall probability (M3), Sowing window as per the current weather forecast, for this season on 35$^{th}$ SMW (M4).It is evident from the study that Sowing sorghum at 38$^{th}$ standard meteorological week based on 75% rainfall probability recorded higher grain yield, rain water use efficiency with elevated iron and calcium content. This shows that different sowing dates have significant influence on grain yield and quality of nutri-millets.*

**Keywords:** Nutri-millets, grain quality, rain dependent, Sorghum, little millet.

## 1. Introduction

The human life mostly depends on the nutrition provided by the food ingestion. However, human food habits vary from region to region and which is dictated by the habitat of food crops grown in different regions. On the other side the problem of malnutrition is also prevalent in many countries which may be due to non-availability of nutrition rich foods, poor access to food and habitat incompatibility for introduced food crops. In future, there is a possibility for shortage of nutrient rich food grains due to various reasons which may lead to the unhealthy society. [1]. Nutri-millets are small coarse of grains belonging to the family poaceae; that can grow in extreme ecological conditions [2]. According to the archaeological and genetic studies most of the millets had their origin in the wide region of Asia and Africa [3, 4, 5]. These crops are the good source of micronutrients besides, the grain bran layer consists of B-complex vitamins. The fibre content in the food grains are also high and have capacity to digest easily. There may be an enormous amount of fat present in the millet rather than the fatty acid [4].

In humans, deficiency of micronutrients may lead to several health issues, which retains the growth of physical and immune system which can be noticed in almost all the developing countries [6]. Further, in African countries like Ethiopia, Nigeria, Uganda, nutria- millets plays a major role and their daily food basket includes 40 percent share of nutria-millets [7]. These millets also have marvelous medicinal uses; even they are used in the treatment of difference diseases like Cancer, Leprosy, and Pneumonia etc., [8]. Here, dietary regulation and monitoring is a major component to avoid further disease complication. India occupies the first position in major production of nutri-millets, but we have less aware of their importance and its nutritional property [9]. Millets are highly nutritious and has antioxidant properties which provide balanced nutrition [10]. Among the nutri-millets, little millet (*Panicum sumatrense* Roth ex Roem. & Schult.) is an important short-duration and hardy native crop that is purely grown in the rainfed situations. In India, little millet is grown to an extent of 2.6 lakh ha with a production potential of 1.2 lakh tonnes, and in the state of Tamil Nadu, it is cultivated in 15411 ha and produces 21079 tonnes of grains [11].

Sorghum [Sorghum bicolor (L.) Moench] enjoys the status of fifth most important coarse cereal crop in the world after wheat, rice, maize and barley and it is native to Africa. It has been an important coarse cereal crop of semi – arid tropical regions of India, because of its multiple uses as grain, fodder, animal feed and more recently as bio – energy crop. Since the crop has grown in wide adaptability, rapid growth and high green fodder yields, it is regarded as a “camel crop”.
In World, sorghum is grown over an area of 42.00 million hectares with a production of 63.21 million tonnes and productivity of 1.50 t ha-1. In India, sorghum occupies an area of 5.00 million hectares with a production of 4.57 million tonnes and productivity of 0.90 t ha-1 and in the State of Tamil Nadu it is extensively grown in various districts encompassing an area of 0.40 million hectare with a production of 0.46 million tonnes and productivity of 851 kg ha-1.
Rainfed farming is the backbone of Indian agriculture, as massive areas of cultivated land is rain dependent. The success or failure of rainfed crops are influenced typically by the pattern of monsoon rains and its distribution. The gamble of monsoon resulting in low productivity of crops and low input use efficiency are the difficulties faced by rainfed farmers. The agro ecology of the semi-arid regions is considerably at risk as the agricultural operations are dependent on the dampness governed by rainfall pattern, amount, and intensity for crop production. Nutri-millets are the most nutritious ancient diet acknowledged by human being. They are drought hardy crops with widespread adaptability to the adverse environmental conditions. Due to prolonged keeping quality under ordinary condition they acquired the status of “famine reserves”. These crops have versatile flexibility to the extreme change in moisture and heat. Nutri-millets can grow fit even under wide range of soils from heavy soils to infertile lands.

## 2. Materials and methods

### 2.1. Study location

The study site is located on countryside of Coimbatore district, named as Annur block, and is situated in Western agro climatic zone of Tamil Nadu which falls under semi-arid tropical climate with a temperature range of 26-41$^{o}$ C. It is located at latitude 11°11’N and longitude 77°01’E at an elevation of 372 mean sea level with the relative humidity of 80%. The wind speed ranges from 7.4 to 12.6 km/hr. It receives an annual rainfall of 546mm, mostly benefitted from northeast monsoon period [12].

### 2.2. Rainfall probability analysis

As a part of the study, 24-hour daily rainfall data (2000-2019) were collected from the Agriculture department, Annur, Tamil Nadu, India and was subjected to statistical analysis using SARIMA Modelling to determine the probability regarding the start and the end of the rainfall in impending calendar year [13]. The resultant data will be employed for decision on sowing dates, suitable crops and land preparation for rain-dependent cropping in the region.

### 2.3. Field experiment

Based on the interpretation from probability analysis using SARIMA model, a field experiment was conducted in a farmer’s field. The experiment was set up in statistical design of Factorial Randomized Block Design (FRBD) with two factors and replicated thrice with 8 treatment combinations. The treatments comprised of crop factor viz., Sorghum [*Sorghum bicolor* (L.) Moench] (C1) and little millet [*Panicum sumatrense* Roth ex Roem. & Schult] (C2) and sowing window factor viz., sowing based farmer’s practice (M1) i.e. on 31st standard meteorological week (SMW); Sowing at 33$^{rd}$ SMW based on 50% rainfall probability (M2); Sowing at 38$^{th}$ SMW based on 75% rainfall probability (M3), Sowing window as per the current weather forecast, for this season on 35$^{th}$ SMW (M4).

### 2.4. Statistical analysis

The data were statistically analysed by means of Fisher's method [14]. All the yield and quality parameters were subjected to analysis of variance (ANOVA) and were analysed with AGRES statistical software.

## 3. Results and discussion

### 3.1. Rainfall probability analysis

The resultant from rainfall probability analysis and modelling revealed that the length of growing season for crops in the study area ranged from 33rd standard meteorological week to 42nd standard meteorological week. The crop management practices like sowing operations, intercultural and application of fertilizers could be followed for kharif season crops from 26th to 39th standard meteorological week in Kenyan highlands [15].

### 3.2. Influence of sowing dates on grain quality of Sorghum and little millet

The harvested grains were transferred to food science laboratory of the college for grain quality assessment. Sowing at 38$^{th}$ standard meteorological week based on 75% rainfall probability (M3) had yielded maximum in sorghum while the minimum grain yield was found in sowing at 33$^{rd}$ SMW based on 50% rainfall probability (M2). As regards to little millet it followed the same trends as that of sorghum due to the greater influence of rainfall on both the millets. Among different dates of sowing tested, 39th standard week sown crop registered higher grain and stover yields in sorghum in Tamil Nadu, India [16].

**Table1. Effect of sowing dates on grain yield**

| **Treatments** | **Grain yield(kg/ha)** | | | | |
|---|---|---|---|---|---|
| | **$M_1$** | **$M_2$** | **$M_3$** | **$M_4$** | **Mean** |
| **Sorghum ($C_1$)** | 672.77 | 479.36 | 880.51 | 753.04 | **696.42** |
| **Little millet ($C_2$)** | 304.79 | 285.45 | 404.58 | 361.65 | **339.12** |
| **Mean** | **488.78** | **382.41** | **642.55** | **557.34** | |
| | **SEd** | | **CD(P=0.05)** | | |
| **C** | 16.78 | | 36.01 | | |
| **M** | 23.74 | | 50.92 | | |
| **C x M** | 33.57 | | 72.02 | | |

The data pertaining to grain quality was depicted in figure 1. From the figure it was inferred that highest Calcium (26.40 mg 100 g $^{-1}$) and Iron content (4.06 mg 100 g $^{-1}$) was recorded when sorghum is sown at 38$^{th}$ standard meteorological week based on 75% rainfall probability (M3).The next best date is sowing based on current weather forecast (M4).This shows that sowing dates has considerable influence on grain quality. [17] inferred that sorghum grains were packed with large proportion of calcium, iron and gluten free protein when compared to cereals like wheat and rice. The highest protein content (11.23g) was recorded in little millet is sown at 38th standard meteorological week based on 75% rainfall probability (M3) followed by sowing based on current weather forecast (M4). Likewise, with reference to Indian institute of millets research (IIMR) the nutritive value of little millet per 100g at 12% moisture was found to be protein (10.1g), calcium (16.1mg) and iron (1.2 mg).

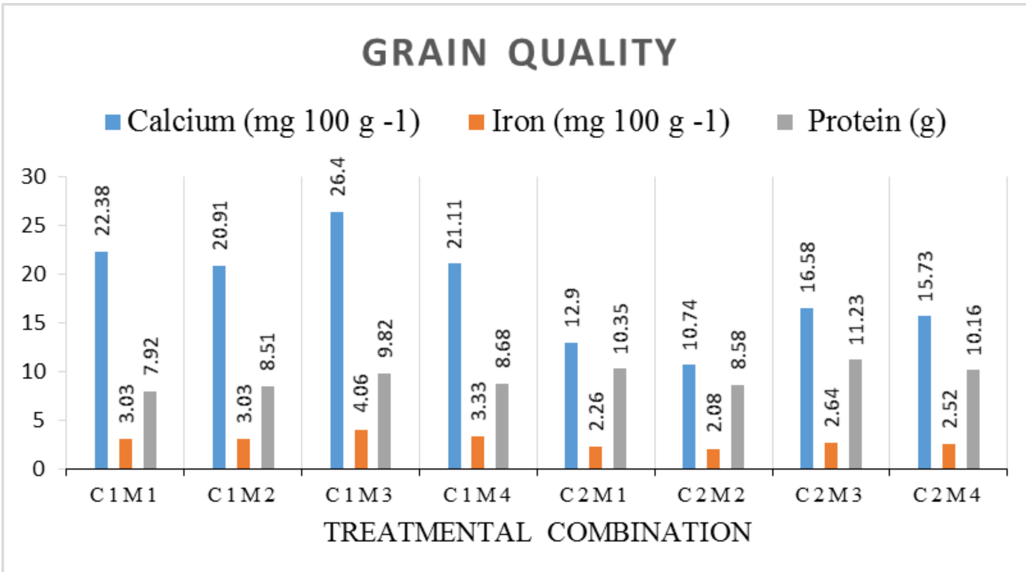


**Figure 1. Effect of sowing dates on grain quality parameters**

### 3.3. Rain water use efficiency

As rain is the chief water for supporting crop growth, among different treatment combinations, highest rain water use efficiency of 4.83kg $ha^{-1}mm^{-1}$ was recorded in sowing sorghum crop at 38th standard meteorological week based on 75% rainfall probability (M3) and was followed by sowing sorghum as per the current weather forecast which was 4.14 kg $ha^{-1}mm^{-1}$ (M4). The lowest rain water use efficiency of 1.57 kg $ha^{-1}mm^{-1}$was recorded on sowing little millet at 33rd SMW based on 50% rainfall probability (M2). Rainwater use efficiency with respect to grain yield was depicted in figure 2.

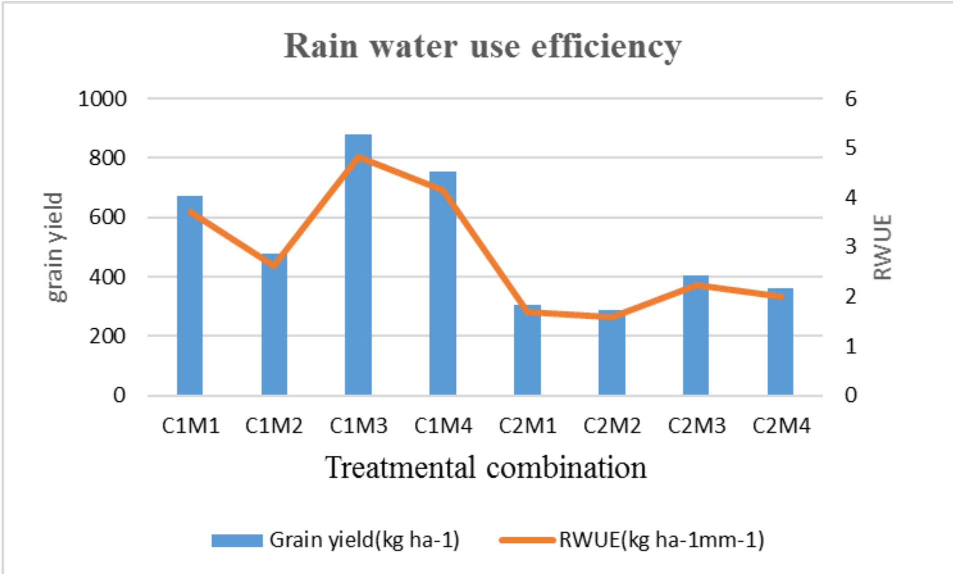


**Figure 2. Influence of sowing dates on rain water use efficiency**

The rain water use efficiency was significantly higher when KCl was applied at flowering and siliqua formation stage with 100% Nitrogen and Phosphorus fertilisation and 75% potassium (K) as basal as compared to control treatment during both the year i.e. 2011-12 and 2012-2013 [18]. Also, In Hyderabad the strategy to apply recommended Nitrogen and Phosphorus fertilisation along with 50% Sulphur, Boron, Zinc (every year) recorded the maximum rain water use efficiency of 5.33 kg $ha^{-1}mm^{-1}$in maize and 2.75 kg $ha^{-1}mm^{-1}$in soybean [19].

## 4. Conclusion

Apart from erratic and uncertain behavior of rainfall, elevated evaporative demand conjoined with poor water holding capacity of soil amount to the prime constraints for crop production in rain dependent areas. From the experimental study conducted under rain-dependent crop production, sowing of nutri-millets 38th standard meteorological week based on 75% rainfall probability has higher productivity and also the maximum content of calcium and iron and protein in the millet grains under rainfed condition. As water availability during crop maturity is essential for filling of grains and its quality, the farmers need to ensure matching of sowing dates with the receipt of rains for better crop establishment, growth and yield.

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