NAMIBIAN AGRONOMIC BOARD

UNAM UNIVERSITY OF NAMIBIA

NAB-UNAM SEED PROJECT

RESEARCH REPORT

SCREENING PEARL MILLET VARIETIES FOR HIGH YIELD UNDER IRRIGATED CONDITIONS IN NAMIBIA

2023/2024 CROPPING SEASON

2024

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1. INTRODUCTION

Pearl millet (*Pennisetum glaucum*), widely known as *mahangu* in Namibia, serves as a staple food for over 60% of the population (Embashu & Nantanga, 2019). This is a significant source of iron and zinc. Pearl millet thrives in harsh agro-climatic conditions where other cereals may struggle without intensive irrigation (Patil, 2018). The Namibian Agronomic Board (NAB), in partnership with the University of Namibia (UNAM), has been evaluating various pearl millet varieties. Seeds from the International Crops Research Institute for Semi-Arid Tropics (ICRISAT) were assessed for their performance under Namibian soil and climate conditions. During the 2021/2022 cropping season, four varieties: SOSAT C88, IP 17645, ICMP 177003, and IP18948 outperformed other pearl millet varieties.

In February 2024, the top four and five other varieties were planted at two trial sites (Mashare and Ogongo) to evaluate their performance under rainfed and irrigated conditions, mainly focusing on grain yield while ensuring seed multiplication, as most of these varieties are new in Namibia. Despite challenges during the 2024 season, such as limited rainfall and late planting, these trials aimed to identify the best-adapted varieties for Namibia's agroecological zones to recommend for commercialisation.

2. RESEARCH OBJECTIVES

i) To screen the pearl millet varieties for high grain yield under irrigation production in Kavango and North Central Production Zones, and to recommend such for commercialisation.

ii) To analyse the longitudinal performances of nine (9) pearl millet varieties across different cropping seasons and planting dates.

iii) To recommend the most promising pearl millet varieties for seed multiplication and commercial grain production in Namibia.

3. MATERIALS AND METHODS

The standard cultivation practices were followed, where the land was prepared by discing and harrowing, and pearl millet seeds were sown manually. In the absence of soil analysis due to time constraints, a basal fertiliser (NPK 2:3:4) and a top-dressing fertiliser (Urea) were applied at minimal rates. Trial fields were irrigated 2 to 3 times a week, depending on the soil moisture content and weather conditions. Mashare used sprinkler irrigation (impact) for all varieties, whereas Ogongo used sprinkler irrigation (Wobbler) on the MS 11 variety and drip irrigation on the IP17645 variety. Experimental layouts, data collection, and data analysis applied are explained under the three (3) subsections outlined below.

3.1 Experimental field layouts

Due to the seed multiplication purpose, which was one of the trial objectives, cross-pollination prevention was a prerequisite during the trial; hence, the study adopted simple screening trials without using a scientific experimental design method. Screening trials were laid out in a manner that each variety was planted until the seeds were finished, before commencing to plant the next variety. At the Mashare trial site, cross-pollination was further prevented by covering the panicles with paper bags. At the Ogongo trial site, two varieties were planted about 100m apart to avoid cross-pollination.

The screening trial was laid out at the Mashare trial site, which was different from the two screening trial layouts at the Ogongo trial sites, which were also different due to different irrigation systems. Due to limited rainfall during the 2024 production seasons, different irrigation systems were used to supplement the rainfall, namely, Sprinkler (impact) irrigation on all varieties at Mashare, as well as Sprinkler (Wobbler) irrigation and drip irrigation at the Ogongo trial site.

At Mashare trial site, the pearl millet varieties planted were as follows; MS 2 (6 rows), IP18948 (3 rows), MS11 (3 rows), SOSATC 88 (1 row), IP1 7645 (1 row), 41518 -k16 (1 row), IP1 700 (1 row), KMP177003 (1 row), and Okashana 2 (6 rows). All varieties at the Mashare trial site were planted according to the spacing of 75cm between rows and 30 cm between plants within a row, whereas the number and row lengths were dependent on the availability of seeds for each variety. Figure 1 presents the layout of a screening trial at the Mashare trial site.

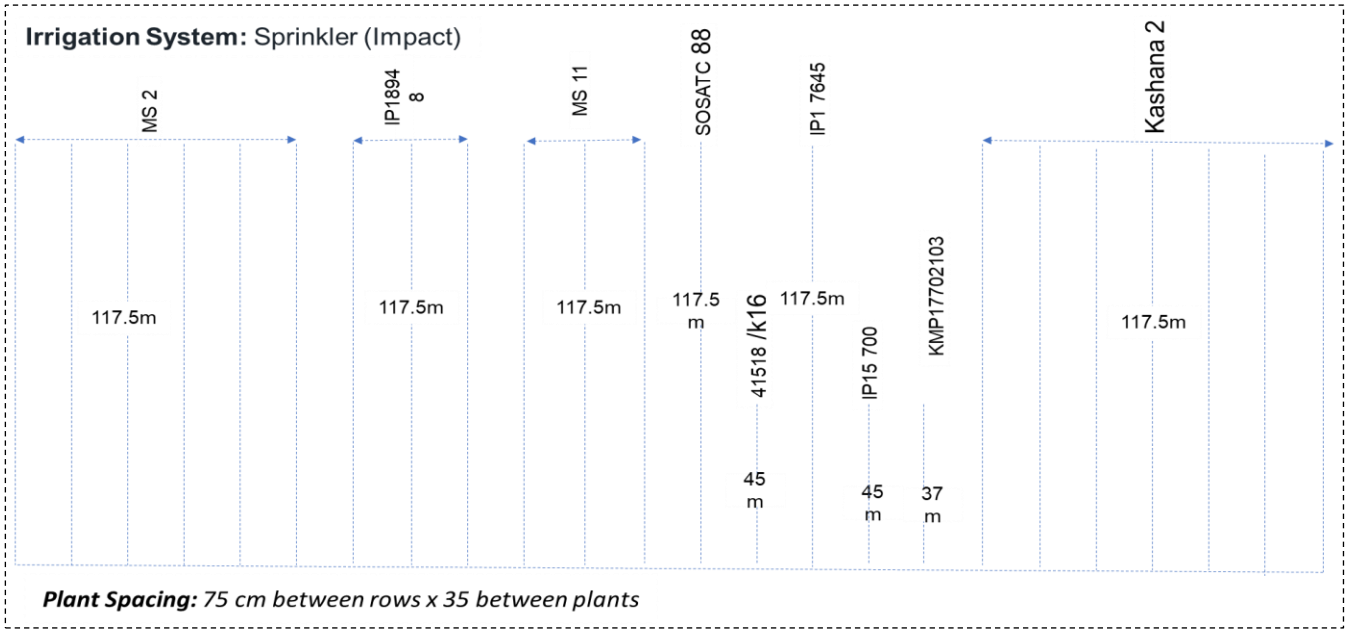


Figure 1: *Layout of screening trial design at Mashare – Planted on the 26th of February 2024*

At the Ogongo trial site, only two varieties were planted due to a lack of seed: MS1 under the sprinkler (wobbler) irrigation system in a field measuring 47.10 m by 40 m, and IP17645 under the drip irrigation system in a field measuring 24.9 m by 49.50 m. The IP17645 variety was spaced 70 cm between rows and 30 cm between plants, while MS 11 was spaced 70 cm between rows and 20 cm between plants. Differences in plant spacing between the varieties were influenced by the irrigation type, although the recommended spacing between rows should be 75–90 cm, with 15–20 cm between plants (ICBA, n.d.). Figure 2 shows the layout of the screening trial under drip irrigation at the Ogongo trials site, while Figure 3 shows the layout of the trial under another condition.

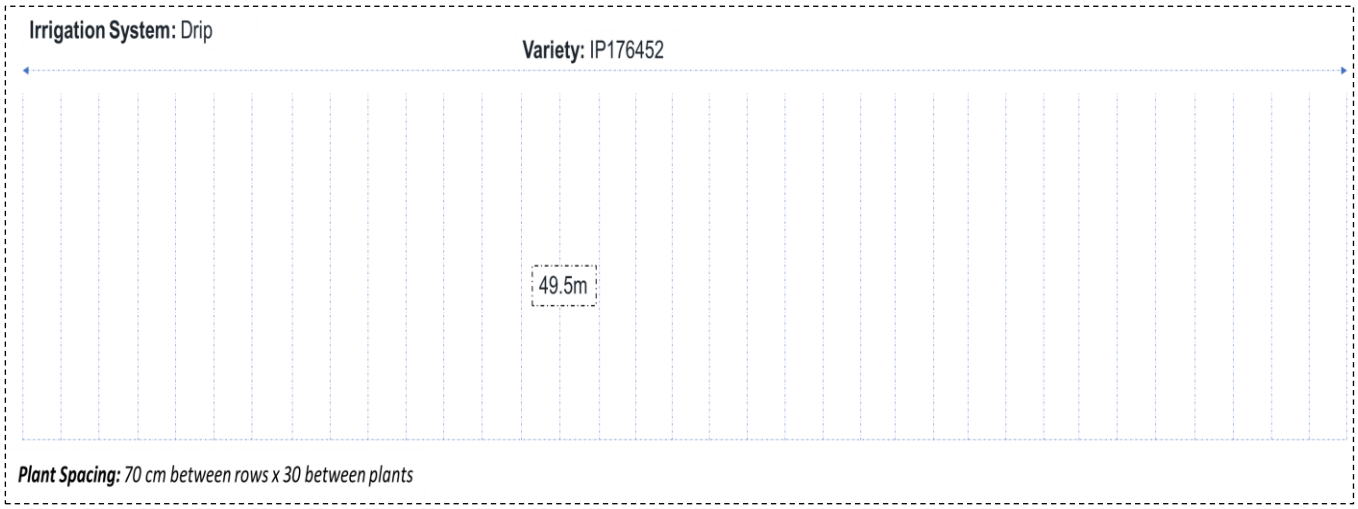


Figure 2: *Layout of the screening trial under drip irrigation at Ogongo – planted on 13 March 2024*

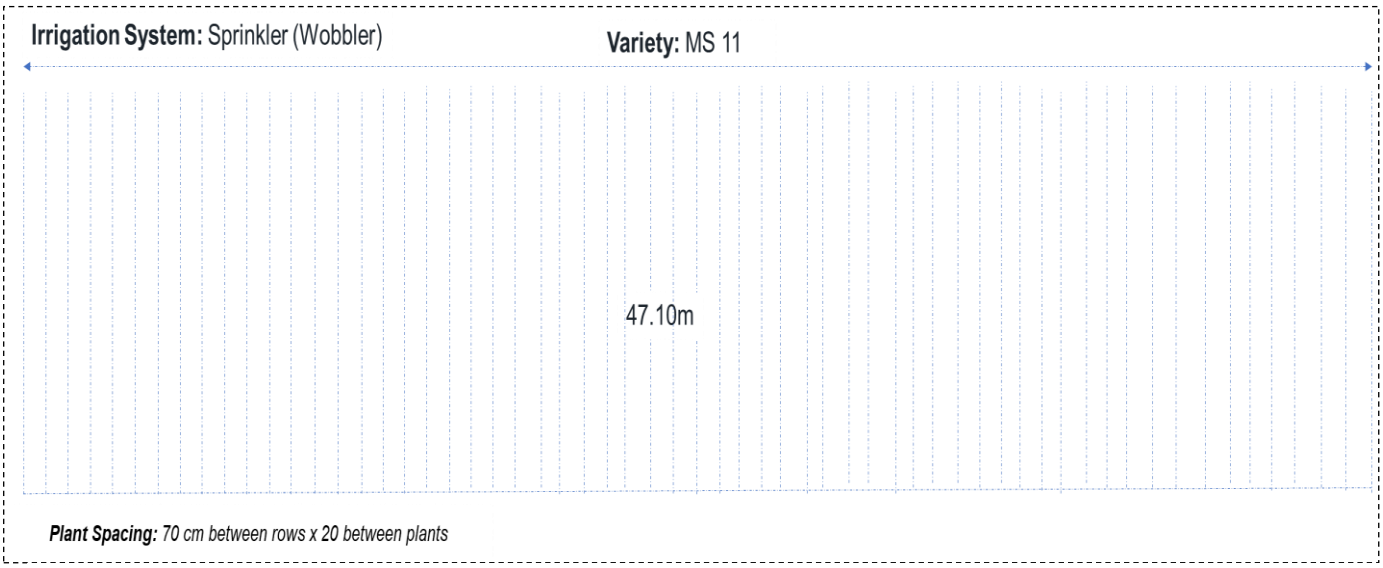


Figure 3: *Layout of screening trial under sprinkler (wobbler) irrigation system at Ogongo - planted on 6 March 2024*

3.2 Data collection

Data were collected on grain yield, days to 50% flowering, and plant height. Differences in irrigation methods were recorded, with Mashare using sprinkler irrigation and Ogongo employing both drip and sprinkler systems on different varieties. Planting dates were also noted to analyse the impact on crop

performance. Table 1 illustrates the *mahangu* trials planting dates at both Ogongo and Mashare in the years 2021, 2022, and 2024. It shows that the trials in 2024 were planted late when compared to trials planted in 2022 and 2021. Cropping season 2022/2023 is excluded as there were no pearl millet planted at these two sites, and those planted at the Dorringboom trial site died due to late planting; hence, they are excluded from this report.

Table 1: Trial sites for pearl millet and their respective planting dates per cropping season

	Planting dates at Mashare trial site per cropping season			**Planting dates at Ogongo trial site per cropping season**		
Variety Name	**2020/2021**	**2021/2022**	**2023/2024**	**2020/2021**	**2021/2022**	**2023/2024**
MS 2	Dec 2020 to Jan 2021	10.02.2022	26.02.24		14.02.2024	
IP18948	Dec 2020 to Jan 2021	10.02.2022	26.02.24	Dec 2020 to Jan 2021	14.02.2024	
MS11	Dec 2020 to Jan 2021	10.02.2022	26.02.24	Dec 2020 to Jan 2021	14.02.2024	06.03.2024
SOSATC 88	Dec 2020 to Jan 2021	10.02.2022	26.02.24		14.02.2024	
41518 /k16	Dec 2020 to Jan 2021	10.02.2022	26.02.24	Dec 2020 to Jan 2021	14.02.2024	
IP1 7645	Dec 2020 to Jan 2021	10.02.2022	26.02.24	Dec 2020 to Jan 2021	14.02.2024	13.03.2024
IP15 700	Dec 2020 to Jan 2021	10.02.2022	26.02.24	Dec 2020 to Jan 2021	14.02.2024	
KMP17702103	Dec 2020 to Jan 2021	10.02.2022	26.02.24	Dec 2020 to Jan 2021	14.02.2024	
Kashana 2	Dec 2020 to Jan 2021	10.02.2022	26.02.24		14.02.2024	

3.3 Data analysis

Descriptive statistics were used to summarise the results. Grain yields from 2024 were compared with those from 2021 and 2022 to identify trends. Parameters analysed included days to 50% flowering, plant height, and grain yields. Although the areas planted for each variety were small, grain yields were converted and reported as tons per hectare.

4. RESULTS AND DISCUSSIONS

This section of the report mainly presents and discusses the results obtained from the trial experiments conducted at both Mashare and Ogongo sites during the 2024 crop season. Historical information on the climate for each site is briefly explained to suggest the ideal planting time for pearl millet in the future. Results on the research parameters, such as days to 50% flowers, plant height, and grain yields, are presented in this section. Results obtained on similar parameters during the 2021 and 2022 cropping seasons are also presented (where possible) for comparisons and discussion purposes.

4.1 Historical climate information at the Mashare and Ogongo trial sites

Pearl millet thrives in warm temperatures, typically between 25°C and 35°C, during growth stages (Sivarajasekar, 2023). This implies that *mahangu* planted in December and January could benefit from the warm temperature from January to March, whereas planting in late February and March would coincide with the declining temperature towards winter, which may affect the yields, despite

supplementing the rainfall with irrigation. Figure 4 shows that the majority of the rainfall at both trial sites (Mashare and Ogongo) has been at peak between December and March, implying December and January to be the best planting months for *mahangu* at both sites, irrespective of whether it is irrigated or rainfed production. *Mahangu* under irrigation may have great potential if planted in December/January, to the latest on 15th February, and otherwise after winter.

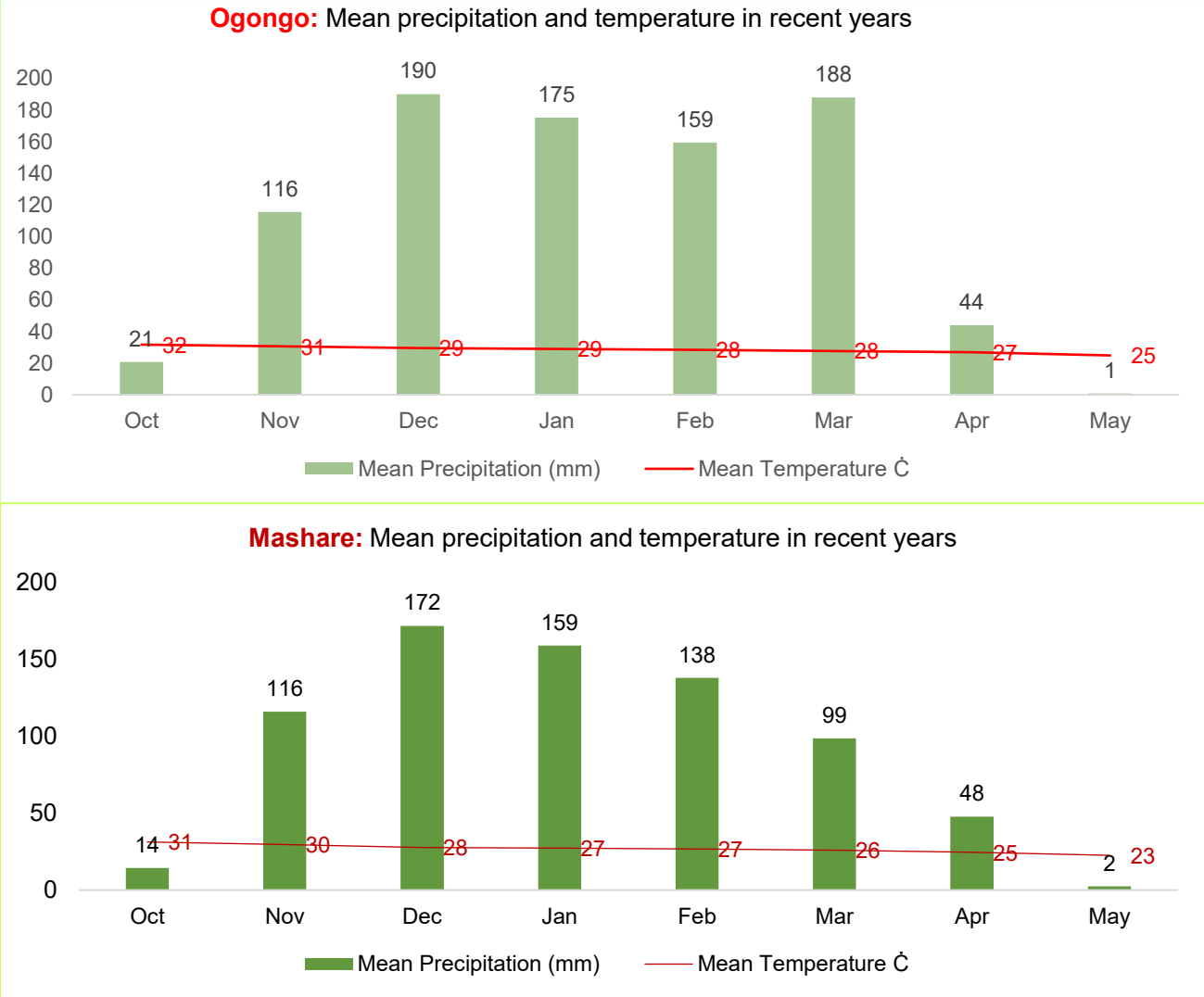


Figure 4: *Mean rainfall and temperature for Ogongo and Mashare trial sites (recent years)*

4.2 Days to 50% flowers

Figure 5 presents the count of days to 50% flowering of plants per variety of pearl millet planted at Mashare in 2022 and 2024. During the 2022 cropping season, results indicate that SOSATC88 (55 days), ICMP 177003 (55 days), and MS2 (55 days) were the earliest-flowering varieties from ICRISAT at the Mashare trial site. Variety 41518/K16 (70 days) was the latest-flowering variety in 2022, followed by IP15700 (59 days). In the 2024 cropping season, MS2 (60) came out as the latest-flowering variety, while it was one of the earliest-flowering varieties in 2022. Okashana 2, as a local

check variety (45 days), was the earliest-flowering variety in 2024. It appears that the flowering date is affected by the planting date, as trials were planted late in 2024.

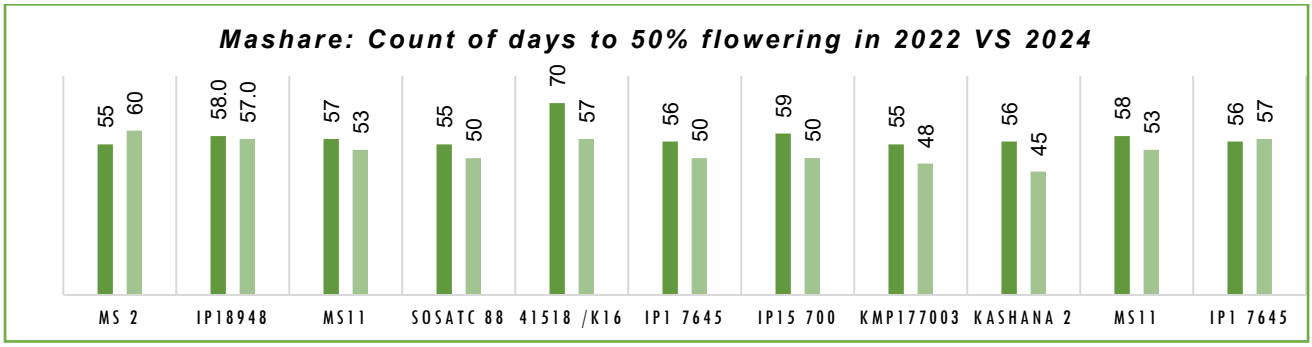


Figure 5: *Count of days to 50% of plants flowering at the Mashare trial site*

4.3 Plant height

Table 2 presents the mean heights of pearl millet varieties planted at Mashare in 2022 and 2024. During the 2022 cropping season, results indicate that MS2 (2.34m) was the tallest variety, followed by SOSAT C88 and MS2, which both attained 2.18m in plant height. In the 2024 cropping season, SOSAT C88 (2.3) came out as the tallest variety, followed by MS2 and IP15700, which both attained 2.1m. On average, over two cropping seasons, SOSAT C88 (2.3m), followed by MS2 (2,2m), were the tallest varieties, whereas 41518/k16 (1.4m) was the shortest variety, with Kashana 2 being the 2nd shortest variety.

Table 2: Mean heights of pearl millet varieties planted at Mashare in 2022 and 2024

Variety	Mean Plant Height (m): 2022	Mean Plant Height (m): 2024	Average (m)	Variance (m)
MS 2	2.34	2.1	2.2	-0.2
IP18948	2.18	1.8	2.0	-0.4
MS11	1.91	1.8	1.9	-0.1
SOSAT C88	2.18	2.3	2.3	0.1
41518 /k16	1.34	1.4	1.4	0.1
IP1 7645	1.88	1.7	1.8	-0.2
IP15 700	1.98	2.1	2.0	0.1
ICMP177003	1.74	1.9	1.8	0.2
Kashana 2	1.89	1.4	1.6	-0.5

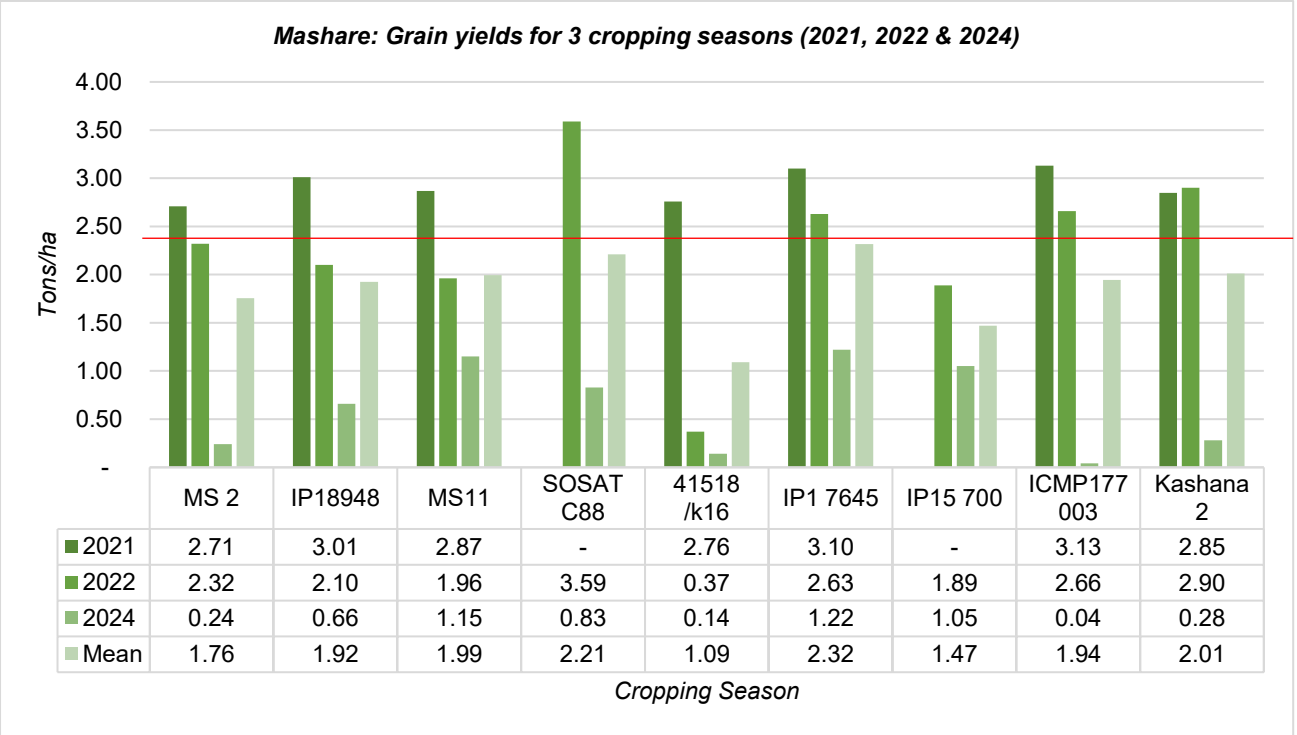
4.4 Grain yield

The late planting of pearl millet in 2024 might have been attributed to low grain yields in this particular cropping season. All varieties planted at both Mashare and Ogongo trial sites attained less than 2 tons/ha, as contrasted to the grain yields obtained from trials in previous years (2021 and 2022). The planting dates in both 2021 and 2022 occurred before the 15th of February at all trial sites, whereas the planting date in 2024 occurred after the 15th of February. Grain yields obtained in 2021 were also higher than the yield of 2022, as planting was done in December/January, as contrasted to the

planting done on the 14th of February in 2022. Varieties such as ICMP177003, IP18948, IP17645, Kashana 2, MS2, and MS 11 have previously exceeded 2 tons/ha in both 2022 and 2021 at Mashare, as presented in Figure 6.

Despite the general low grain yields attained across all varieties planted in the 2024 cropping season, IP17645 (1.22 tons/ha) was the highest variety in grain yield in 2024, followed by MS 2 (1.15 tons/ha) and IP15700 (1.05 tons/ha). The rest of the varieties attained less than a ton/ha, with ICMP177003 (0.04 tons/ha) being the least prolific amongst other pearl millet varieties planted in the 2024 cropping season.

Despite the challenges faced in the 2024 cropping season, four out of nine varieties planted at Mashare managed to surpass the average grain yield of over 2 tons per hectare across three cropping seasons. These are: IP17645 (2.32 tons/ha), SOSAT C88 (2.21 tons/ha), Kashana 2 (2.01 tons/ha), and MS11 (1.99 tons/ha). ICMP1770 variety, which recorded the highest yield at Mashare in 2021, failed to reach 2 tons per hectare on average, solely due to very poor performance in 2024.



	MS 2	IP18948	MS11	SOSAT C88	41518 /k16	IP1 7645	IP15 700	ICMP177 003	Kashana 2
2021	2.71	3.01	2.87	-	2.76	3.10	-	3.13	2.85
2022	2.32	2.10	1.96	3.59	0.37	2.63	1.89	2.66	2.90
2024	0.24	0.66	1.15	0.83	0.14	1.22	1.05	0.04	0.28
Mean	1.76	1.92	1.99	2.21	1.09	2.32	1.47	1.94	2.01

Figure 6: *Grain yields obtained from mahangu trials at Mashare*

Figure 7 shows that only two pearl millet varieties were planted at the Ogongo site during the 2024 cropping season. Due to unforeseen challenges such as late planting and quelea birds experienced throughout the season, grain yields were very low and insignificant for both varieties, with yields below 0.2 tons/ha. However, four of the eight pearl millet varieties planted at the Ogongo site on different

occasions achieved an average yield of 2 tons/ha; these are namely, IP18948 (3.63 tons/ha), 41518/K16 (2.46 tons/ha), IP 15700 (2.45 tons/ha), and ICMP177003 (2.45 tons/ha).

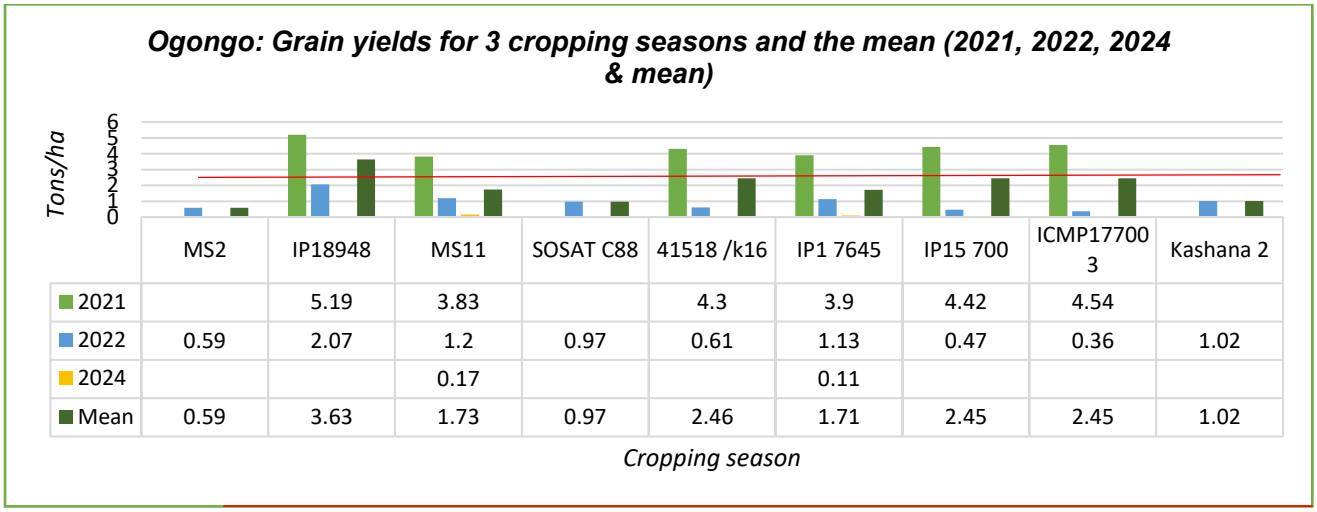


Figure 7: Grain yields (Tons/ha) obtained from mahangu trials at Ogongo

Given the longitudinal comparisons of mean grain yield attained from each variety over 3 cropping seasons, the IP18948 variety (2.78 tons/ha) was the top performer, whereas MS 2 was the least performer. Okashana 2 (1.52 tons/ha), as a check variety, was the second last performer amongst the 9 varieties trialled.

Table 5: Mean average and ranking of pearl millet trialled over 3 cropping seasons

Variety	Mashare	Ogongo	Average	Rank
MS 2	1.76	0.59	1.17	9
IP18948	1.92	3.63	2.78	1
MS11	1.99	1.73	1.86	5
SOSAT C88	2.21	0.97	1.59	7
41518 /k16	1.09	2.46	1.77	6
IP1 7645	2.32	1.71	2.02	3
IP15 700	1.47	2.45	1.96	4
ICMP177003	1.94	2.45	2.20	2
Kashana 2	2.01	1.02	1.52	8

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The 2024 cropping season came with its unique challenges of limited rainfall and extremely high heat waves experienced during March and April 2024, whereas the trial crops were planted late in February and early March in 2024. This resulted in low grain yields being attained from field trials of the 2024 cropping season, as contrasted to the good yields obtained in the 2021 and 2022 cropping seasons. The issue of late planting also coincided with the quelea bird's competition for the grain yield. As all other farmers have already harvested, quelea birds tend to severely attack fields that are still with

grains at a milky stage when the rest of the fields in the same area are already harvested. Despite the efforts to cover the heads of mahangu plants with paper bags, quelea birds were still eating the mahangu grains from the field, which ultimately affected the true grain yield performance of the varieties in the trials. Hence, results for the 2024 cropping season trials do not fit for publication, as their grain yield performances are extremely inconsistent with the other two previous cropping seasons.

In terms of mean grain yields, the four top pearl millet variety performers amongst the 9 trialed varieties were: IP18948 (2.78/ha), ICMP177003 (2.2 tons/ha), IP 17645 (2.02 tons/ha), and IP17645 (1.96 tons/ha). Other varieties also resulted in satisfactory mean grain yields, namely, MS 11 (1.86 tons/ha), 41518 /k16 (1.77 tons/ha), SOSAT C88 (1.59 tons/ha), and Okashana 2 as a local variety (1.52 tons/ha). In order of top performance, SOSAT C88, Okashana 2, ICMP 177003, and MS 11 lead in terms of short maturity days amongst the 9 pearl millet varieties under trial. The most prolific variety from the trials was the 2nd tallest variety among others, which is IP18948, whereas the tallest variety was among the varieties with satisfactory grain yields, which is SOSAT C88.

5.2 Recommendations

I. Given the poor performance of the 2024 cropping season trials, researchers propose to plant another trial between December 2024 and January 2025, which should be irrigated and applied with the correct types and amounts of fertilisers.
II. The NAB/UNAM seed project team should sample the soil from trial sites in November 2024 for analysis and calculation of fertiliser requirements, and such fertilisers should be procured by mid-December 2024.
III. The NAB/UNAM seed project team should plant the next pearl millet variety trials between December 2024/January 2025 and again in August 2025 under irrigation.
IV. The NAB/UNAM seed project team has to prepare data collection sheets for use by Research Technicians, and these should be similar at all trial sites.
V. Data collection sheets for the next trials should include: planting date, grain yield, plant height, flowering date, agronomic score, and grain size, inputs (seed, fertilisers, other agro-chemicals, irrigation, etc.) in terms of name, quantity, cost, frequency of applications, etc.
VI. Upon completion of the next trial in the upcoming cropping season, a Pearl Millet Enterprise Budget should be produced by the NAB/UNAM seed project team to assess the profitability of irrigated pearl millet.
VII. If the purpose of pearl millet trials also includes seed multiplication, varieties should be isolated for at least >50m apart, to avoid cross-pollination.

VIII. Next trials should establish the best irrigation method, best fertiliser application rate, best variety under different irrigation methods, and the cost of pearl millet production under irrigated vs rain-fed conditions.

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