

## Research Article

# Effect of Integrated Technologies on Production and Productivity of Pearl Millet in the Dryland Areas of Wag Himira Administrative Zone, Eastern Amhara, Ethiopia

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Production of pearl millet with yield improvement would have a direct impact on the drought-prone areas of Ethiopia since pearl millet is drought tolerant and early maturing with high water use efficiency. An experiment was conducted to study the performance of pearl millet under different technologies in 2013 and 2014 main cropping seasons at the main site of the research center, Aybra, with the objective of evaluating and identifying appropriate combinations of technologies that enhance the production of pearl millet in the study area. About fourteen integrated technologies were applied in a randomized complete block design with three replications. The analysis was done by using SAS software version 9.1, and means were separated through the Duncan multiple range test. Results of analysis of variance showed that yield-related traits of pearl millet were significantly influenced by the integration of technologies in the 2013 cropping season. According to the results, the maximum yield ( $3084 \text{ kg ha}^{-1}$ ) was recorded with the application of the treatment combination of recommended fertilizer application + seed priming + tie ridging, while the minimum was recorded ( $919 \text{ kg ha}^{-1}$ ) in the treatment combination of microdose application of fertilizer + primed seed + intercropping of pearl millet with mung bean. In the case of the 2014 cropping season, the highest grain yield ( $3687 \text{ kg ha}^{-1}$ ) was recorded with the treatment combination of microdose fertilizer application + primed seed + tie ridging + intercropping of pearl millet with mung bean, whereas the lowest grain yield ( $2115 \text{ kg ha}^{-1}$ ) was recorded in the treatment combination of no fertilizer application + primed seed + flat bed. Based on the results of the current investigation, it could be recommended that using technology integration of microdose, tied ridge, primed seed, and intercropping of pearl millet with mung bean is better to attain maximum yield in the study area and similar agroecologies.

## 1. Introduction

Pearl millet (*Pennisetum glaucum*) is the most important crop in the drier parts of semiarid tropics and accounts for almost half of the global production of different millet species cultivated. As a general estimate, global millet production is broken down into pearl millet (50%), finger millet (10%), and other millets (40%). Over 30% of the population (over 100 million people) of Eastern and Central Africa (ECA) live in these semiarid areas and rely on agriculture and livestock as their main livelihood (Omamo et al., 2006).

The communities in these areas depend on millets and sorghum as the main staple crop providing sources of food

and income. As the conditions become drier, pearl millet is the only crop that is grown where normal rainfall does not permit the reliable production of sorghum. Production exceeds that of sorghum due to its drought-tolerant character, and the reverse is the case as rainfall increases. Being able to thrive on harsh habitats, pearl millet is perhaps the best of all life-supporting grain (FAO, 1992).

Concerning its nutritional value, research was conducted by Hambidge (2013). According to the study, pearl millet bread contains more iron, which can provide young children their full daily iron needs. His report further pointed out that it yields reliably well in too hot and too dry regions to consistently support a good yield of maize or sorghum. Pearl

millet is a hardy warm-season, dryland cereal grain crop. It is largely grown in the drought-prone regions of Africa and Asia where it performs better than other cereals. It can also be grown in harsh environments and give higher grain and biomass yield where other crops perform and give yield poorly. In Ethiopia, one improved variety has been released by the name of Kola-1 for production in the dryland areas of the country. Though the crop is grown in some dry areas of the country, agronomic factors that limit pearl millet productivity are not yet studied.

Wag-Himra administrative zone is one of the known dryland areas in Ethiopia. Especially the low land areas of the zone receive rainfall characterized by erratic in distribution and limited amount which has a pattern of late on setting and early offsetting for the cropping seasons. The topography of the area is undulated with a high percentage of soil degradation and low soil fertility status.

Production of pearl millet with yield improvement would have a direct impact on the drought-prone areas of Ethiopia since pearl millet is drought tolerant and early maturing with high water use efficiency. Especially in Wag Himira Zone, production of pearl millet needs critical attention since drought is the major problem in this area because moisture is the limiting factor for crop production in general and pearl millet production in particular. Accordingly, Sekota Dryland Agriculture Research Center has recommended this Kola-1 variety through adaptation with its intrarow and interrow spacing. Even though this crop has a potential of giving yield up to 22 qt ha<sup>-1</sup> in other areas, its productivity in the study area is not more than 12 qt ha<sup>-1</sup>. This necessitates further research work to maximize the production and productivity of pearl millet in the study area by the integration of different technologies. Therefore, this research work was initiated with the objective of evaluating and identifying appropriate combinations of technologies that enhance the production of pearl millet in the study area.

## 2. Materials and Methods

The experiment was conducted at Aybra testing sites of Sekota Dryland Agricultural Research Center in Eastern Amhara region, Ethiopia, for two consecutive years (2013-2014) during the main cropping season. The Aybra testing site is characterized by an altitude of 1976 m.a.s.l., minimum and maximum temperatures of 26.6°C and 31.6°C, respectively, and an average annual rainfall of 650 mm with the latitude of 12.68°N' and longitude of 39.015°E. The treatments considered in the study consisted of integration of fourteen technologies such as no application of fertilizer + dry seed + flatbed, no application of + dry seed + tied ridge, application of recommended fertilizer rate + dry seed + flatbed, application of recommended fertilizer rate + primed seed + flatbed, application of recommended fertilizer rate + primed seed + tied ridge, microdose application of fertilizer + dry seed + flatbed, microdose application of fertilizer + dry seed + tied ridge, microdose application of fertilizer + primed seed + flatbed, microdose application of fertilizer + primed seed + tied ridge, microdose application of fertilizer + primed seed + tied ridge + intercropping of

pearl millet with mung bean, and microdose application of fertilizer + primed seed + tied ridge + intercropping of pearl millet with haricot bean. The design of the experiment was randomized complete block design with three replications of plot size of 5 m length and ×3 m width. The spacing between plots and replications was 0.5 m and 1.5 m, respectively. The Kola-1 variety for pearl millet, Awash-1 variety for haricot bean, and Rasa variety for mung bean were used as a testing crop for the experiment. Important agronomic practices such as land preparation and weeding were uniformly applied to all experimental plots as often as required. Days to heading, days to maturity, panicle length (cm), plant height at maturity (cm), number of effective tillers per plant, thousand seed weight (gm), biomass yield (tonnes ha<sup>-1</sup>) and grain yield (qt ha<sup>-1</sup>) were collected. The collected data were subjected to analyses of variance (ANOVA) using SAS version 9.1. As illustrated by Gomez and Gomez [8], testing the homogeneity of error variance using an F test with Genstat software was performed to decide whether the data should be combined or not. Mean separation for statistically different treatments was done using Duncan's multiple range test (DMRT) at 0.05 level of significance depending on the ANOVA result.

## 3. Soil Physicochemical Property

Soil analysis was conducted before the commencement of the experiments, based on the laboratory result, the pH of the area for which the experiment was conducted is 5.96 resulted from the procedure of filtered suspension of 1:2.5 soil to water ratio using a glass electrode attach to pH meter. In addition, regarding the textural class, the site is clay loam and the organic matter was with the range of 1.09 and besides this total nitrogen was measured by micro-Kjeldahl digestion, distillation, and titration method and has a value of 0.84 (Table 1).

### 3.1. Treatments

- (1) No fertilizer + dry seed + flat bed
- (2) No fertilizer + dry seed + tied ridge
- (3) No fertilizer + primed seed + flat bed
- (4) No fertilizer + primed seed + tied ridge
- (5) Recommended fertilizer rate + dry seed + flat bed
- (6) Recommended fertilizer rate + dry seed + tied ridge
- (7) Recommended fertilizer rate + primed seed + flat bed
- (8) Recommended fertilizer rate + primed seed + tied ridge
- (9) Microdose + dry seed + flat bed
- (10) Microdose + dry seed + tied ridge
- (11) Microdose + primed seed + flat bed
- (12) Microdose + primed seed + tied ridge
- (13) Microdose + primed seed + tied ridge + intercropping (mung bean)
- (14) Microdose + primed seed + tied ridge + intercropping (haricot bean)

TABLE 1: Soil physicochemical property.

Site	PH	ECdec/m	OM	TN (%)	Texture			Textural class
					Sand	Silt	Clay	
Aybra	5.96	1.8	1.09	0.84	33	32	35	Clay loam

TABLE 2: Effect of integrated technologies on the productivity of pearl millet at Aybra in the 2013 main cropping season.

Treatments	DH	SCH	PH (cm)	NTPP	LP (cm)	BMY (ton ha <sup>-1</sup> )	TKW (gm)	GY (kg ha <sup>-1</sup> )
No F + DS + FB	67.00	118.5A	129.70	1.20	14.60	4.90D	9.00	1061.0GH
NF + DS + TR	71.00	96.0A	144.10	3.40	17.90	7.80BCD	8.70	1831.0DCEF
NF + PS + FB	66.00	103.67A	148.30	2.00	16.30	6.60CD	9.70	1549.10DEFG
NF + PS + TR	70.00	97.0A	142.00	2.80	17.40	9.30ABC	9.30	2036.40DC
RFR + DS + FB	70.00	105.5A	148.30	1.85	17.20	6.20CD	9.80	1325.0EFGH
RFR + DS + TR	70.00	118.3A	154.30	2.20	18.30	12.40A	9.00	2851.40AB
RFR + PS + FB	69.00	115.0A	170.30	2.40	17.80	9.20ABC	12.50	1693.6DEF
RFR + PS + TR	71.30	113.0A	173.70	1.40	19.30	12.50A	10.80	3084.30A
MD + DS + FB	67.00	111.3A	157.50	2.50	18.30	9.20ABC	9.20	1879.10DCE
MD + DS + TR	68.60	63.3B	138.50	3.10	17.20	6.80BCD	9.50	1549.70DEFG
MD + PS + FB	67.00	118.0A	147.80	1.80	17.00	6.10CD	8.80	1270.80FGH
MD + PS + TR	70.60	96.0A	161.30	2.70	17.50	10.90AB	11.30	2378.90BC
MD + PS + TR + IMB	70.50	95.0A	142.50	1.60	15.90	7.80BCD	9.00	919.70H
MD + PS + TR + IHB	69.60	96.67A	144.50	1.30	17.20	7.30BCD	8.70	1466.3DEFGH
Duncan (at 5%)	NS	**	**	NS	NS	**	NS	**
CV (%)	3.60	12.70	6.10	48.20	9.10	26.30	21	20.40

DH = days to heading; SCH = stand count at harvest; PH = plant height; NTPP = number of tillers per plant; LP = length of panicle; BMY = biomass yield; TKW = thousand kernel weight; GY = grain yield.

#### 4. Result and Discussion

Results of analysis of variance showed that day to 50% heading was not significantly ( $P > 0.05$ ) influenced by integration of different technologies at Aybra in both seasons to maturity (Tables 2 and 3). On the contrary, to phenological parameters, integration of technologies had significantly affected the number of tillers and plant height in both seasons. The highest plant height (173.00 cm) was recorded in the integration of fertilizer + primed seed + tied ridge, while the lowest (129.20 cm) was recorded in the treatment combination of no fertilizer application + dry seed + flat bed in 2013. This might be due to the terminal moisture deficit for the plant to be stunted; the same is true in the case of tie ridge which does not expose the plant moisture deficits and, as a result, the plant became tall as compared to that in the flatbed. Similarly, during the 2014 cropping season, the highest plant height (168.66 cm) was recorded with the treatment combination of applying the recommended fertilizer rate + dry seed + tied ridge as compared to no fertilizer application + primed seed + flatbed with a plant height of (137.00 cm). This result is in agreement with the findings of Mutiso et al. [11] where the plant height of pearl millet was highest with the treatment combination of recommended fertilizer with tie ridge. The number of tillers was statistically significantly affected by the integration of technologies in 2014. The maximum number of tillers (2.33) was recorded in the treatment combination of the application of recommended fertilizer rate + dry seed + tied ridge, whereas the minimum (0.80) was recorded in the application of no fertilizer + dry seed + flat bed. The current results are in harmony with the previous findings of Singh et al. [12] who found

that soil moisture conservation practices, tie ridging, and furrow practices recorded maximum plant height and dry matter accumulation in plants. In the 2013 cropping season, plant height was not significantly influenced by the integration of technologies. Yield related trait of pearl millet was significantly affected by the integration of technologies (Table 2). According to the results, the maximum yield (3084 kg ha<sup>-1</sup>) was recorded with the application of the treatment combination of recommended fertilizer application + seed priming + tied ridge, while the minimum was recorded (919 kg ha<sup>-1</sup>) in the treatment combination of microdose application of fertilizer + primed seed + intercropping of pearl millet with mung bean. With regard to biological yield, the maximum (12.4 ton ha<sup>-1</sup>) was recorded in the treatment combination of the recommended application of fertilizer + primed seed + tied ridge, whereas the minimum (4.9 ton ha<sup>-1</sup>) was recorded in a combination of no fertilizer application + dry seed + flatbed. In the case of the 2015 cropping season, the highest grain yield (3687 kg ha<sup>-1</sup>) was recorded with the treatment combination of microdose fertilizer application + primed seed + tied ridge + intercropping of pearl millet with mung bean, whereas the lowest grain yield (2115 kg ha<sup>-1</sup>) was recorded in the treatment combination of no fertilizer application + primed seed + flatbed (Table 3). Similarly, biomass yield was the highest (21.10 ton ha<sup>-1</sup>) in the case of the treatment combination of microdose fertilizer application + primed seed + flatbed. However, the lowest biomass yield (11.15 ton ha<sup>-1</sup>) was recorded with the treatment combination of no fertilizer application + dry seed + tied ridge (Table 3). This result is in line with the findings of Rao et al. [13] who have reported that straw yield was higher by 63% and 25% over a flatbed.

TABLE 3: Effect of integrated technologies on the productivity of pearl millet at Aybra in the 2014 main cropping season.

Treatments	DH	PH	NT	PL	HW	BM (ton ha <sup>-1</sup> )	SW (gm)	GY (kg ha <sup>-1</sup> )
No F + DS + FB	64.33a	152.93bcd	0.80d	17.00abc	91.83a	15.29cde	9.50a	2227fg
NF + DS + TR	65.66a	148.80cde	2.20abc	19.20a	112.67a	11.15e	10.50a	3413ab
NF + PS + FB	63.00a	137.00e	0.80d	15.33c	120.83a	17.75abcd	10.50a	2115g
NF + PS + TR	65.33a	146.73de	2.66a	18.80ab	100.00a	11.23e	10.50a	2683def
RFR + DS + FB	65.66a	169.13ab	1.40bcd	17.8abc	106.33a	15.20cde	9.83a	3339ab
RFR + DS + TR	65.33a	168.66ab	2.33ab	18.93ab	120.67a	16.49bcde	11.16a	3463ab
RFR + PS + FB	65.00a	167.53ab	0.80d	18.00ab	120.33a	22.21a	10.83a	2572defg
RFR + PS + TR	65.33a	163.73abc	1.66abcd	18.80ab	110.00a	13.56de	11.16a	3152bc
MD + DS + FB	64.00a	176.00a	0.80d	17.80abc	121.33a	19.73abc	10.50a	2309efg
MD + DS + TR	65.66a	155.33bcd	2.06abc	18.93ab	119.00a	13.37de	9.83a	2724cde
MD + PS + FB	64.33a	162.13abcd	1.06cd	18.46ab	109.17a	21.10ab	9.66a	2179g
MD + PS + TR	64.66a	158.46bcd	1.53abcd	18.53ab	116.17a	16.56bcde	10.66a	2872cd
MD + PS + TR + IMB	64.66a	165.26ab	1.80abcd	19.33a	100.00a	12.71de	10.83a	3687a
MD + PS + TR + IHB	65.00a	167.46ab	1.46bcd	17.13abc	105.17a	13.12de	9.83a	3406ab
Mean	64.85	159.9	1.52	18.05	110.96	15.67	10.38	28.67
CV	2.49	5.33	39.43	7.67	23.93	18.46	12.81	8.77
Duncan (at 5%)	NS	**	**	**	NS	**	NS	**

DH = days to heading; SCH = stand count at harvest; PH = plant height; NTPP = number of tillers per plant; LP = length of panicle; BMY = biomass yield; TKW = thousand kernel weight; GY = grain yield.

Furthermore, the current result is found to be in agreement with the findings of Singh et al. [12] who have reported that tied ridging increased sorghum grain yield and soil water by more than 40%. According to their results, during a season with moderate intensity rainfall, open and tied ridge increased sorghum yield by 67–73% over the control.

## 5. Conclusion and Recommendations

The result of this study indicates that using a different integration of technologies had no significant effect on days to heading and thousand kernel weight. On the other hand, plant height, number of tillers per plant, biomass yield, and grain yield were significantly affected by the integration of technologies in the 2013 cropping season. In the similar year, the recommended fertilizer rate + primed seed + tied ridge gave a higher grain yield (3084 kg ha<sup>-1</sup>), whereas the integration of no fertilizer application and sowing of seed without priming (dry seed) on a flatbed gave the lowest grain yield (1061 kg ha<sup>-1</sup>). In the 2014 cropping season, both days to heading and straw yield were not significantly affected by technology integration. However, the integration of microdose + primed seed + tied ridge + intercropping of pearl millet with mung bean gave the highest grain yield (3687 kg ha<sup>-1</sup>) as compared to the integration of no fertilizer application + primed seed + flatbed which gave 2115 kg ha<sup>-1</sup>.

Based on the results of the current investigation, it could be recommended that using technology integration of microdose, tied ridge, primed seed, and intercropping of pearl millet with mung bean is better to attain maximum yield in the study area and similar agroecologies.

## Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

## Conflicts of Interest

The authors declare that they have no conflicts of interest.

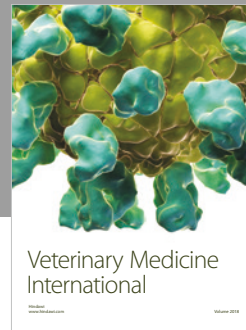
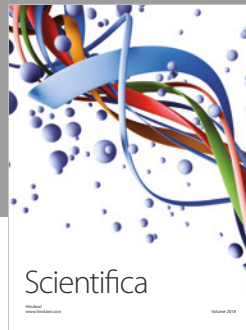
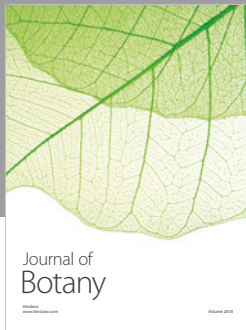
## Authors' Contributions

Tafere Berhanu, Wubeshet Beshir, and Alemu Lakew contributed equally to this study.

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