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Full Length Research Paper

Assessment of pearl millet performance to early and late planting opportunities and fertilizer application models in Makurdi, Nigeria

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Assessment of time of planting and fertilizer application models on Pearl millet (*Pennisetum glaucum*) performance was studied at the Teaching and Research Farm of the University of Agriculture Makurdi, Benue State, Nigeria. The experiment was made of ten (10) fertilizer models and two (2) planting dates. The study was laid out in a randomized complete block design (RCBD) with three replicates. Soil properties were determined prior to experimentation. Seed yield and panicle length were taken at harvest. The result indicates that early planting gave significantly (< 0.05) higher leaf area, plant height and grain yield than the late planted opportunity. Application of 60:30:30 kg NPK/ha alone gave higher seed yield of 1516.5 and 1250.0 kg/ha in 2008 and 2009, respectively than other treatments. The yield obtained however, was not statistically different from application of 40:20:20 kg NPK/ha + 3 t/ha of PM. Early planting of millet and application of 60:30:30 kg/ha or 40:20:20 kg NPK/ha + 3 t/ha of PM is hereby recommended for millet production in Makurdi, Nigeria.

Key words: Pearl millet, yield, organic manure, inorganic fertilizer, panicle length.

INTRODUCTION

Pearl millet is described as one of the most important cereal in the Sahel and the Northern Sudan, and the second most important cereals in the Southern Sudan and Northern Guinea and third most important in the Southern Guinea Savanna region. In Nigeria, the yield of pear millet has declined. The decline in yield is attributed to low fertility status of the soil resulting from continuous cropping, incidence of pests and unfavorable weather resulting to uncertainty in planting opportunities (Odo and Bibinu, 1998). In recent times, many soil fertility improvement techniques have been recommended, which included adoption of appropriate and adequate fertility packages involving the use of organic and inorganic fertilizer as well as planting at the right time. Combined application of organic manure with inorganic fertilizer reduces the quantities of both required (Parr et al., 1990).

Previous studies demonstrated significant effect of combined application of organic and inorganic fertilizer as well as time of application on growth performance and yields of maize and other crops and soil nutrients (Norwal and Antil 2005). There is paucity of information as regards pearl millet performance to combined application of organic manure and inorganic fertilizer and time of planting in Makurdi, Nigeria. Hence, the objective of this study was to investigate the effect of application of varying combinations of poultry manure (organic manure) and NPK fertilizer (inorganic fertilizer), and early as well as late planting periods on growth performance and yield of pearl millet in Makurdi, Nigeria.

MATERIALS AND METHODS

Experimental site

The field experiment was conducted at the Teaching and Research Farm of the University of Agriculture Makurdi during the 2008 and 2009 cropping season. Makurdi falls within latitude 7° 41' N and longitude 8° 37' E at an elevation of about 97 m above sea level in the Southern Guinea Savanna agro ecological zone of Nigeria, and has two distinct seasons; wet and dry; the wet seasons starts from April and end in October, with mean annual rainfall of 1250 mm and mean temperature of 28°C (Idoga et al., 2005). The textural class of

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the soil is sandy loam and it is generally coarse textured especially in the surface horizons and well to moderately drain.

Experimental treatments and design

The experiment consisted of ten fertilizer treatments and two planting periods as follows: (1) Control (no application); (2) NPK 40:20:20 (kg/ha) alone; (3) NPK 40:20:20 (kg/ha) + 1.5 tonnes PM/ha; (4) NPK 40:20:20 (kg/ha) + 3.0 tonnes PM/ha; (5) NPK 60:30:30 (kg/ha) alone; (6) NPK 60:30:30 (kg/ha) + 1.5 tonnes PM/ha; (7) NPK 60:30:30 (kg/ha) + 3.0 tonnes PM/ha; (8) NPK 80:50:50 (kg/ha) alone; (9) NPK 80:50:50 (kg/ha) + 1.5 tonnes PM/ha; 10) NPK 80:50:50 (kg/ha) + 3.0 tonnes PM/ha [PM = poultry manure; planting periods: early planting (April) and late planting (August)].

The treatments were laid out in a randomized complete block design (RCBD) and replicated three times. The land was cleared and ridges constructed at a spacing of 1.0 m apart. The area of land used for the experiment measured 1861.5 m^2, whereas the individual plots measured 25 m^2 each. Poultry manure (dry) was evenly spread on appropriate plots and worked into the soil during tillage. The manure was allowed to decompose two weeks before planting (WBP). The inorganic fertilizer was applied two weeks after planting (WAP). Five seeds of millet were planted per hole at a spacing of 0.75 × 1.0 m and were later thinned to two seedlings per hole at two weeks after planting, giving a plant population of 26,667 stands per hectare. Planting was carried out in April (early planting) and in August (late planting). Weeding was done at 2 and 7 WAP in each of the cropping year.

Plant height and leaf area were collected at 3, 6, 9 and 12 WAP while panicle length and seed weight were measured at harvest. Heights of the plants were measured using a measuring tape. Four plants were randomly selected in each plot and the mean height was recorded as the representative height for each plot. Leaves from four plants were selected for the determination of leaf area using a measuring tape, the length and width of the leaf were obtained and leaf area calculated as the product of the length and width. The panicle lengths of four randomly selected plants were measured using a measuring tape at harvest. Grain yield per plot was measured using a weighing balance.

Before planting in 2008, surface (0 to 15 cm) soil samples were collected from 20 points and bulked. The soil sample was analyzed (measured) for the following: the pH was determined both in water (1:2) and in 0.01 calcium chloride ($CaCl_2$) solution (1:2). Particle size distribution was determined by the hydrometer method. Total nitrogen was determined by macro-Kjeldahl method (Black, 1965). The organic carbon was determined using Walkley and Black (1934) method, and phosphorus (P) by Bray-1 procedure (Bray and Kutz, 1945). The exchangeable bases: calcium (Ca), potassium (K), magnesium (Mg) and sodium (Na) were determined using the titration method (Black, 1965). The effective cation exchange capacity (ECEC) was calculated as the sum of the exchangeable bases (Black, 1965). Chemical analysis of poultry manure (dry) used for the experiment was also carried out.

Crop data collected were subjected to regression and analysis of variance and the means that were statistically different were separated using Fisher's least significant difference (F-LSD) (Obi, 1986).

RESULTS AND DISCUSSION

Soil properties of the study site

Data summarizing the properties of soil as well as that of the poultry manure used for the field study are shown in Table 1. The soil of the experimental site was sandy loam. The soil was adequate in pH (6.4), low cation exchange capacity (2.09) and high available phosphorus. The values for total N and organic matter all fall within the critical low range in soils of southern guinea savanna (Donahue et al., 1990). With low N, organic matter and low CEC, it is obvious that the soil is inherently low in fertility and therefore, expected to exhibit response to fertilizer application. With this result notwithstanding, the soil was considered suitable for cultivation of millet which according to Onwueme and Sinha (1991), can be grown on all types of soil and does not strikingly respond to fertilizer treatment.

Response of pear millet to time of planting and fertilizer application

Leaf area

Table 2 presents the main effect of time of planting and fertilizer application on leaf area of pear millet. Late planted millet produced significantly lower leaf area than early planted millet in 2008 and 2009 cropping seasons. Paired t-test analysis showed significant year effect at three weeks after planting in which year 2008 produced higher leaf area than year 2009. Application of NPK 80:50:50 + 3.0 tonnes of poultry manure per hectare (T_{10}) produced plants with higher leaf area during the two cropping seasons from six to nine weeks after planting. This is an indication that nutrient from poultry manure and inorganic fertilizer was effectively utilized by millet. However, the performance of T_{10} was statistically the same as application of NPK 80:50:50 + 1.5 tonnes of PM per hectare (T_9) and NPK 80:50:50 (T_8) at all intervals was considered. The lowest leaf area was obtained from the controlled treatment (T_1) in both years. Interaction effect between time of planting and fertilizer rate was only significant ($P < 0.005$) at 3 and 9 WAP in 2008 cropping season (Table 3). Application of NPK 60:30:30 and NPK 80:50:50 + 3.0 tonnes poultry manure per hectare to early millet planting significantly produced higher leaf area than other treatments.

Plant height

Main effect of time of planting and fertilizer application on height of pearl millet is presented in Table 4. Early planted millet gave significantly taller plants than late planted pear millet in 2008 and 2009 cropping seasons. Paired t-test analysis indicates a significant year effect at 9 and 12 weeks after planting. The tallest plants were obtained from application of NPK 80:50:50 + 3.0 tonnes of PM per hectare. This showed that pearl millet was able to efficiently utilize nutrients in the combined application of poultry manure and NPK fertilizer. However, application of NPK 80:50:50 + 1.5 tonnes of PM per

Table 1. Some physical and chemical properties of the soil and poultry manure before experiment.

Parameter	Soil	Dry poultry manure
Sand (%)	85.0	-
Silt (%)	11.70	-
Clay (%)	3.30	-
pH (H_2O 1:1)	6.40	-
pH (0.01 N $CaCl_2$ 1:2)	5.60	-
Organic matter (%)	2.08	-
Organic carbon (%)	1.04	-
Total nitrogen (%)	0.07	4.48
Available $P_{(ppm)}$	22.65	1.98
Mg (cmol kg^{-1})	0.43	0.39
Ca (cmol kg^{-1})	1.20	7.63
Na (cmol kg^{-1})	0.30	-
K (cmol kg^{-1})	0.16	1.53
ECEC (meq 100 g^{-1})	2.09	-

Table 2. Main effect of time of planting and fertilizer application on leaf area of pearl millet at Makurdi, Nigeria.

Treatment	3 WAP		6 WAP		9 WAP		12 WAP	
	2008	2009	2008	2009	2008	2009	2008	2009
Early	137.6	120.8	322.0	221.1	419.4	347.8	419.3	356.8
Late	30.7	19.5	102.0	185.4	292.3	256.3	294.9	348.3
Mean	84.2	70.2	212.0	203.3	355.8	302.1	357.1	302.6
LSD (0.05)	1.50	6.15	15.96	6.81	12.42	18.34	137.5	18.20
T- test (0.05)	4.72*		-0.63^{ns}		-5.18^{ns}		-0.17^{ns}	
T_1	73.4	71.3	174.8	139.1	307.9	258.0	308.6	256.4
T_2	76.3	68.7	191.0	156.1	313.0	261.7	316.0	261.5
T_3	68.4	65.5	194.9	178.0	317.5	264.3	327.2	265.0
T_4	73.2	69.1	199.8	194.2	324.4	279.8	323.2	276.0
T_5	98.1	69.8	206.3	208.2	327.4	289.8	327.5	289.9
T_6	84.3	69.4	214.2	213.2	380.2	304.5	381.0	304.0
T_7	81.1	71.6	220.0	225.6	385.4	316.6	385	319.3
T_8	82.1	69.1	237.1	229.0	392.6	325.4	392.2	325.2
T_9	87.5	69.4	238.4	236.4	401.2	352.1	401.0	352.2
T_{10}	90.9	69.1	243.4	252.7	409.2	368.8	409.2	368.6
LSD (0.05)	NS	NS	35.69	15.24	27.77	41.01	13.75	40.70
T-test (0.05)	0.14^{ns}		0.09^{ns}		1.0^{ns}		1.78^{ns}	

* = Significant at P < 0.05; Ns = not significant,

Table 3. Interaction effect of time of planting and fertilizer application on leaf area of millet at Makurdi, Nigeria.

Treatment		3 WAP		6 WAP		9 WAP		12 WAP	
Time of planting	Fertilizer rate	2008	2009	2008	2009	2008	2009	2008	2009
Early	T_1	125.3	124.0	271.0	157.3	405.0	306.0	405.2	306.5
	T_2	123.3	119.3	296.0	172.0	408.0	312.1	408.0	312.0
	T_3	124.0	114.0	303.2	204.0	410.7	314.0	410.0	312.0
	T_4	126.0	120.3	306.3	220.1	416.1	336.0	414.3	338.6
	T_5	160.1	123.0	313.6	230.1	416.8	342.6	416.9	342.8

Table 3. Contd.

	T_6	153.3	120.7	328.0	232.0	420.2	356.3	422.0	356.0
	T_7	125.0	124.7	330.2	238.4	424.0	360.4	424.0	360.6
	T_8	139.3	121.0	355.0	242.0	424.8	362.3	424.0	362.3
	T_9	141.3	121.0	356.4	246.7	430.4	386.1	430.0	386.2
	T_{10}	158.0	120.2	360.3	268.0	438.0	402.0	438.4	402.2
	T_1	21.4	18.5	78.6	120.8	120.8	210.0	212.0	210.2
	T_2	29.3	18.0	86.0	140.2	218.0	211.2	224.0	211.0
	T_3	12.9	17.0	86.6	152.0	224.3	214.6	224.3	214.8
	T_4	20.0	17.9	93.2	168.3	232.0	223.6	232.0	224.1
	T_5	36.1	16.5	99.0	186.3	238.0	237.0	238.0	237.0
Late	T_6	15.3	18.1	100.4	194.3	340.1	252.7	340.0	252.0
	T_7	32.1	18.5	109.6	212.7	346.8	274.9	346.0	278.0
	T_8	24.8	17.2	119.2	216.0	360.4	288.4	360.4	288.0
	T_9	33.6	17.7	120.3	226.1	372.0	318.0	372.0	318.2
	T_{10}	23.7	17.9	126.5	237.3	380.4	335.6	380.0	335.0
	LSD (0.05)	19.44	NS	NS	NS	39.27	NS	NS	NS

Ns = Not significant.

Table 4. Main effect of time of planting and fertilizer application on plant height of pearl millet at Makurdi, Nigeria.

Treatment	3 WAP		6 WAP		9 WAP		12 WAP	
	2008	2009	2008	2009	2008	2009	2008	2009
Early	33.9	29.8	159.3	150.7	250.7	227.3	251.2	231.6
Late	26.2	27.5	127.6	126.1	216.1	199.2	218.4	201.2
Mean	30.0	28.6	143.5	138.4	233.4	213.2	234.8	216.4
Lsd (0.05)	2.11	8.40	4.67	46.6	9.41	3.98	6.19	7.57
T- test	-0.42^{ns}		9.07^{ns}		9.07		8.84*	
Fertilizers rate								
T_1	29.8	27.1	128.4	121.4	204.4	188.0	210.0	189.3
T_2	31.0	26.4	131.7	128.4	216.9	200.4	217.5	202.9
T_3	31.3	27.0	136.6	131.6	220.6	207.2	221.7	205.9
T_4	29.3	28.2	137.7	135.7	227.5	212.5	228.9	212.5
T_5	24.8	28.7	143.0	141.8	235.8	214.7	237.8	216.2
T_6	30.1	27.8	146.0	142.9	240.1	216.5	240.2	219.5
T_7	30.0	26.5	150.7	143.5	243.2	217.5	246.0	222.7
T_8	29.5	27.9	151.0	144.5	244.7	222.0	247.4	224.9
T_9	28.7	27.0	153.0	147.6	247.4	225.9	249.0	227.2
T_{10}	28.8	27.5	156.3	150.3	250.6	227.8	251.7	228.9
LSD (0.05)	NS	NS	10.43	10.42	21.04	8.90	13.84	16.92
T-test (0.05)	0.24^{ns}		-1.0^{ns}		5.0^{ns}		10^{ns}	

*=Significant at P < 0.05; ns = not significant.

hectare and NPK 80:50:50 to millet gave plants heights that were statistically the same. The shortest plant height was obtained from the control treatment (T_1). These observations agreed with that of Awodun et al. (2007) that leaf area, plant height and grain yield of pepper were significantly increased with application of organic fertilizer enriched with inorganic fertilizer in south western Nigeria. Singh et al. (2007) also noted a significant increase in height of pearl millet in India with application of organic manure in conjunction with nitrogen and phosphorus fertilizer. Plant height responded significantly to interaction between fertilizer application and time of planting at 6 WAP in year 2008 and 2009 (Table 5). Application of NPK 60:30:30 + 3.0 tonnes of poultry

Table 5. Interaction effect of time of planting and fertilizer application on plant height of millet at Makurdi, Nigeria.

Treatment		3 WAP		6 WAP		9 WAP		12 WAP	
Time of planting	**Fertilizer rate**	**2008**	**2009**	**2008**	**2009**	**2008**	**2009**	**2008**	**2009**
Early	T_1	33.4	30.2	132.0	122.6	226.6	197.7	229.2	198.6
	T_2	36.3	28.9	138.0	133.9	232.0	217.1	222.0	222.0
	T_3	36.9	28.8	147.0	139.2	234.0	222.3	235.9	228.0
	T_4	32.1	31.3	148.6	145.4	243.0	229.0	243.8	235.0
	T_5	38.3	32.7	159.0	156.7	256.6	229.5	257.2	235.6
	T_6	33.6	29.2	164.7	158.8	256.9	231.3	259.0	238.0
	T_7	33.6	27.4	133.1	159.3	260.0	231.9	262.0	238.4
	T_8	32.4	30.7	173.4	160.9	263.1	235.0	263.3	238.8
	T_9	30.9	29.0	177.3	167.1	264.3	237.8	265.0	240.0
	T_{10}	31.5	30.0	179.5	170.1	268.8	241.0	268.8	241.2
Late	T_1	26.2	24.0	124.8	120.2	182.2	178.2	190.7	180.0
	T_2	25.3	23.9	125.3	122.9	201.7	183.7	203.0	183.7
	T_3	25.6	25.1	126.4	124.0	207.2	192.0	207.5	190.0
	T_4	26.4	25.0	126.8	125.9	211.9	196.0	214.0	196.8
	T_5	26.0	25.0	127.0	126.8	215.0	199.8	218.3	201.0
	T_6	26.6	26.0	127.3	127.0	221.3	201.6	221.3	207.0
	T_7	26.3	25.5	128.3	127.6	226.1	203.0	230.0	211.0
	T_8	26.5	25.0	128.6	128.0	230.5	209.0	231.4	211.9
	T_9	26.5	25.0	128.7	128.1	232.0	214.0	232.9	214.3
	T_{10}	26.1	25.0	133.0	130.4	233.5	214.5	234.6	216.5
	LSD (0.05)	NS	NS	12.75	12.04	NS	NS	NS	NS

Ns=Not Significant,

manure per hectare combined with early planting, gave higher plant height than other treatments combinations

Effect of time of planting and fertilizer application on panicle length and grain yield of millet

Table 6 shows the main effect of time of planting and fertilizer application on panicle length and grain yield of pearl millet. Early planted millet produced significantly (< 0.005) higher panicle length both in 2008 and 2009 than late planted period. Similarly, grain yield was significantly higher when pearl millet was planted early. In terms of panicle length, year 2008 performed significantly better than year 2009. Significant year effect was however not observed with respect to grain yield. Application of NPK 60:30:30 gave higher grain yield compared to other treatments. This showed that although pearl millet was able to efficiently utilize nutrients in the combined application of poultry manure and NPK fertilizer, this does not go on indefinitely. The low grain yield recorded with application of NPK 60:30:30 + 3.0 t/ha, NPK 80:50:50, NPK 80:50:50 + 1.5 t/ha and NPK 80:50:50 + 3.0 tonnes poultry manure can be attributed to “excess” N., over-supply of which often result to excessive vegetative or foliar growth at the expense of reproductive development, thereby affecting the grain yield. This phenomenon has been reported by several authors (Plaster, 1992; Brady and Well, 2007; Agbede et al., 2008).

Interaction effect was only significant with respect to panicle length in 2009 (Table 7). Correlation analysis between leaf area and other crop parameters show that leaf area of millet at 3 WAP correlated positively and significantly with all plant parameters evaluated. Plant height of millet at 3 weeks after planting correlated positively and significantly with grain yield and leaf area at all intervals. There was no significant correlation between plant height of millet at 3 WAP and panicle length of millet. However, a positive and significant correlation existed between plant height and panicle length of millet at 6, 9 and 12 weeks after planting. The correlation analysis also showed negative correlation between grain yield and panicle length of millet. This may be due to the fact that panicle length of pearl milletdoes not strikingly respond to fertilizer application (Table 8).

Conclusion

The influence of time of planting and fertilizer application on growth and yield of pearl millet was studied at the Teaching and Research Farm of the University of Agriculture Makurdi, Benue State, Nigeria. The experiment was a 10 × 2 randomized complete block design

Table 6. Main effect of time of planting and fertilizer application on panicle length and grain yield of millet at Makurdi, Nigeria.

Treatment	Panicle length		Grain yield	
Time of planting	**2008**	**2009**	**2008**	**2009**
Early	31.07	29.70	1080.5	984.3
Late	27.30	24.83	732.8	630.3
Mean	29.20	27.27	906.7	807.3
LSD (0.05)	0.94	0.52	123.1	121.9
T- test (0.05)	5.18*		0.15^{ns}	
Fertilizer rate				
T_1	23.8	22.7	858.0	812.5
T_2	26.0	24.9	929.5	905.9
T_3	27.9	26.2	1064.0	1006.5
T_4	28.1	26.6	1400.5	1171.9
T_5	29.2	26.9	1516.5	1250.0
T_6	29.6	27.6	1315.0	1165.0
T_7	30.6	28.4	696.5	676.5
T_8	31.3	28.8	479.0	454.2
T_9	31.6	29.6	396.0	357.0
T_{10}	32.1	30.5	284.8	236.6
LSD (0.05)	2.70	2.15	275.2	262.6
T-test (0.05)	1.47^{ns}		0.54^{ns}	

* = Significant at P < 0.05; ns = not significant.

Table 7. Interaction effect of time of planting and fertilizer application on panicle length and grain yield of millet at Makurdi, Nigeria.

Treatment		Panicle length		Grain yield	
Time of planting	**Fertilizer rates**	**2008**	**2009**	**2008**	**2009**
Early	T_1	24.7	23.3	1035.0	998.0
	T_2	29.7	26.8	1116.0	1089.0
	T_3	29.7	28.8	1348.0	1268.0
	T_4	29.8	29.4	1686.0	1519.6
	T_5	31.3	30.0	1718.0	1532.0
	T_6	31.6	30.2	1642.0	1402.0
	T_7	32.5	31.0	943.0	808.9
	T_8	33.5	31.5	541.0	499.8
	T_9	33.8	32.5	436.0	431.0
	T_{10}	34.1	33.0	340.0	295.0
Late	T_1	22.8	22.1	681.0	627.0
	T_2	26.9	23.0	743.0	722.8
	T_3	26.0	23.6	780.5.0	745.0
	T_4	26.5	23.6	1159.0	981.2
	T_5	27.0	24.4	1315.0	1020.0
	T_6	27.6	25.0	988.0	928.0
	T_7	28.7	25.8	659.0	585.0
	T_8	24.0	26.0	417.0	410.8
	T_9	29.3	26.6	359.5	283.0
	T_{10}	30.1	28.0	22.95	178.1
LSD(0.05)		NS	1.63	NS	NS

NS = Not significant.

Table 8. Correlations between pearl millet, growth parameters and grain yield of pearl millet.

Crop data	GRY	PANL	PLH_{12}	PLH_9	PLH_6	PLH_3	LA_{12}	LA_9	LA_6	LA_3
LA_3	0.4 51*	0.535*	0.759**	0.825**	0.835**	0.952**	0.925**	0.818**	0.931**	-
LA_6	0.191	0.785**	0.925**	0.961**	0.926**	0.849**	0.994**	0.957**	-	
LA_9	0.029	0.855**	0.94**	0.966**	0.870**	0.735**	0.970**	-		
LA_{12}	0.199	0.790**	0.922**	0.965**	0.914**	0.847**	-			
PLH_3	0.576**	0.437	0.664**	0.744**	0.701**	-				
PLH_6	0.122	0.826**	0.935**	0.927	-					
PLH_9	0.125	0.910**	0.975**	-						
PLH_{12}	0.048	0.937**	-							
PANL	-0.164	-								
GRY	-									

* = Significant at P < 0.05, ** = Significant at P < 0.01; LA_3, leaf area at 3 WAP; LA_6, leaf area at 6 WAP; LA_9, leaf area at 9 WAP; LA_{12}, leaf area at 12 WAP; PLH_3, plant height at 3 WAP; PLH_6, plant height at 6 WAP; PLH_9, plant height at 9 WAP; PLH_{12}, plant height at 12 WAP; PANL, panicle length; GRY, grain yield.

with three replications. The result indicates that early planting gave significantly (< 0.05) higher grain yield than the late planted one. Application of 60:30:30 kg NPK/ha gave higher seed yield of 1516.5 and 1250.0 kg/ha in 2008 and 2009, respectively than other treatments. The yield obtained however, was not statistically different from application of 40:20:20 kg NPK/ha + 3 t/ha of PM.

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