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Research Paper

Effect of integrated nutrient-management and dates of sowing on nutrient uptake and yield of pearl millet (*Pennisetum glaucum*)

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ABSTRACT

A study was conducted at during the rainy season of 2014 and 2015 at Hyderabad, Telangana, to study the effect of integrated nutrient management and dates of sowing on pearl millet (*Pennisetum glaucum*). Pearl millet crop was raised with 3 integrated nutrient management as main treatments, i.e. M_1 [100% recommended dose of fertilizer (RDF), M_2 (100% RDF + FYM @ 5 t/ha) and M_3 (100% RDF + pressmud @ 2.5 t/ha), and 4 sowing dates as subtreatments, viz. D_1, 15 June; D_2, 30 June; D_3, 15 July and D_4, 30 July. Out of the 3 integrated nutrient-management treatments, 100% RDF + pressmud @ 2.5 t/ha, i.e. M_3, improved the growth parameters, viz. plant height, dry-matter production and, leaf-area index, as well as yield attributes like ear length, weight of grains/ear and 1,000–grain weight which consequently resulted in the highest grain, straw yield, harvest index and nutrient uptake of pearl millet in comparison to the other main treatments. Among dates of sowing, pearl millet sown on 30 June (D_2) recorded greater plant height (162.1 cm), dry-matter production (8305 kg/ha), leaf-area index (1.66), ear length (26), weight of grains/ear (16.2) and 1,000-grain weight (7.2), as well as grain yield (3242), straw yield (5360), and harvest index (38.1) compared to other dates of sowing during both the years of experiment.

Key words **:** Pearl millet, Integrated nutrient management, Dates of sowing, Nutrient uptake, Yield

Millets are major food sources for millions of people, especially those who live in hot, dry areas of the world. They are grown mostly in marginal areas in which major cereals fail to give substantial yields. Pearl millet in India is cultivated as dual purpose (food and fodder) crop.

In India, major producing states are Rajasthan (46%), Maharashtra (19%), Gujarat (11%), Uttar Pradesh (8%) and Haryana (6%). The area under pearl millet in Telangana state is about 0.08 lakh ha, with production of 0.07 lakh tonnes, having productivity of 875 kg/ha (Department of Agriculture, Telangana, 2015–16). The productivity of pearl millet is very low as compared to important pearl millet-growing countries in world. It is, therefore, necessary to increase the production and productivity of pearl millet by adopting scientific innovations.

Sowing time is the most important non-monetary input influencing crop yield. Sowing very early in season may not be advantageous. Also delayed sowing invariably reduces crop yield. Sowing the crop at optimum time increases yield owing to suitable environment at all the growth stages of the crop. Flowering is induced after sufficient vegetative growth. Moisture stress or dry spells may be avoided during critical growth stages. Therefore, optimum sowing time plays an important role in production of pearl millet crop. Intensive cultivation, growing of exhaustive crops, use of unbalanced and inadequate fertilizers accompanied by restricted use of organic manures have made the soils not only deficient in the nutrients, but also deteriorated the soil health. Under such condition, integrated nutrient management (INM) has great importance and has vital significance for the maintenance of soil productivity. The pearl millet gives reasonable yields even on marginal soils of arid and semi-arid areas, where other crops would fail due to hot and dry climates. Due to continuous adoption of the nutrient-exhaustive crops and imbalanced use of fertilizers, production of the cropping system is either declining or remaining stable in the state. In order to enhance the productivity of the system, there is growing realization to introduce organic sources of nutrient along with chemicals. (Walia *et al*., 2010).

Therefore the present study is proposed to enhance the crop productivity with organic and inorganic fertilizers at optimum time of sowing in pearl millet.

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MATERIALS AND METHODS

The study was conducted during the rainy (*kharif*) seasons of 2014 and 2015 at College Farm, College of Agriculture, Professor Jayashankar Telangana State Agricultural University (PJTSAU), Rajendranagar, Hyderabad. The site is geographically situated at 17° 19' N, 78° 28' E, and at an altitude of 542.3 m above mean sea-level). According to Troll's climatic classification, it falls under semi-arid tropics.

The experiment was laid out in a strip-plot design with 3 replications during the rainy season, keeping integrated nutrient-management sources, 100% recommended dose of fertilizer (RDF; M_1), 100% RDF + FYM @ 5 t/ha (M_2) and 100% RDF + pressmud @ 2.5 t/ha (M_3) as main treatments and sowing dates, viz. 15 June (D_1), 30 June (D_2), 15 July (D_3) and 30 July (D_4) as subtreatments Pearl millet hybrid of 'PHB 3' was used. The recommended doses of fertilizer (RDF), i.e. 60, 30 and 20 kg N, P_2O_5 and K_2O/ha was applied through urea, single superphosphate (SSP) and muriate of potash (MoP), respectively. Entire P_2O_5 and K_2O were applied basal by placement and covered with the soil and 50% of recommended nitrogen was applied basal and the remaining was top-dressed at 30 days after sowing (DAS). In Pressmud, available nutrients were nitrogen 1.37–1.57 %, phosphorus 0.56–0.62% and Potassium 1.23–1.51% and in farmyard manure (FYM) these were 0.65–0.72%, 0.46–0.48% and 1.04–1.07%, respecetively.

The rainfall received during the *kharif* season of 2014 was 443.3 mm in 30 rainy days. The weekly mean maximum temperature ranged from 27.5°C to 37.1°C, having the highest in 24th standard week and the lowest in 36th standard week. The mean minimum temperature ranged from 19°C to 24.9°C, with minimum in 26th standard week and upper value in 43rd standard week. In 2015, during *kharif* pearl millet crop-growth period, the total rainfall received was 475 mm spread over 33 rainy days. The mean weekly minimum and maximum temperature ranged from 18.1° C in 43rd standard week to 24.6°C in 24th standard week and 28.4 °C in 37th standard week to 34.8 °C in 28th standard week respectively.

Date of sowing, i.e. 30 June, had resulted in higher yield than other dates of sowing, because of good rainfall at vegetative growth stage resulting in higher tiller production. The amount of rainfall received at growth stage 2 was though low, but due to uniform distribution of rainfall and rainy days spread from flowering to grain development had led to higher grain yield of pearl millet.

RESULTS AND DISCUSSION

Plant height

The pooled data revealed that as the plant height (153.3 cm) of pearl millet significantly increased as plant growth advanced owing to 100% RDF + pressmud @ 2.5 t/ha(M_3) treatment at harvesting stage. Significantly greater plant height of pearl millet was recorded with 30 June sowing date (D_2), followed by 15 July (D_3), 15 June (D_1) and the minimum plant height was recorded at 30 July (D_4) sowing date (Table 1). Interaction effect of plant height of pearl millet crop as influenced by integrated nutrient management and dates of sowing was non-significant at all crop-growth stages.

Dry-matter production

Nitrogen supplied through the inorganic and organic sources like 100% RDF + press mud @ 2.5 t/ha significantly improved the dry-matter accumulation at harvesting

Table 1. Effect of integrated nutrient management and dates of sowing on growth parameters of pearl millet at harvesting (pooled over 2014 and 2015)

Treatment	Plant height (cm)	Dry-matter production (kg/ha)	LAI	No. of effective tillers/m^2
Integrated nutrient management				
M_1, 100% RDF	126.7	6,349	1.15	18.3
M_2, 100% RDF + FYM @ 5 t/ha	141.5	7,138	1.37	20.7
M_3, 100% RDF + Pressmud @ 2.5 t/ha	153.3	7,837	1.57	22.8
SEm±	2.5	236	0.03	0.55
CD (P=0.05)	9.6	812	0.12	1.99
Date of sowing				
D_1, 15 June	133.3	6,662	1.21	19.7
D_2, 30 June	162.1	8,305	1.66	23.5
D_3, 15 July	151.4	7,580	1.52	21.7
D_4, 30 July	115.3	5,884	1.05	17.4
SEm±	2.6	217	0.03	0.7
CD (P=0.05)	9.1	754	0.10	1.9

RDF, Recommended dose of fertilizer

(Table 1). Dry-matter accumulation is the result of higher metabolic activity of the plants and solar energy harvesting efficiency of plants due to optimum sowing time like 30 June, i.e. D_2 coupled with favourable climate conditions, especially temperature, rainfall and solar radiation which produced higher dry-matter (pooled data) as the plant growth advanced at harvesting. Interaction effect between nutrient management and sowing dates was non-significant for dry-mater production at all the growth stages.

Effective tillers/m²

Data pertaining to effective tillers/m^2 as affected by integrated nutrient-management and different dates of sowing are presented in Table 1. Pooled mean of both the years with respect to integrated nutrient management treatments, 100% RDF + pressmud @ 2.5 t/ha (M_3) significantly recorded highest number of effective tillers/m^2 followed by 100% RDF + FYM @ 5 t/ha (M_2) and 100% RDF (M_1) (Table 1).

Maximum number of effective tillers/ m^2 were observed when pearl millet crop was sown on 30 June, while the minimum when pearl millet crop was sown on 30 July (Table 1).

Leaf-area index

Application of 100% RDF + pressmud @ 2.5 t/ha in the maximum leaf-area index at harvesting stage, being significantly higher than the other treatments. Similarly, the highest leaf-area index was recorded with the D_2 date of sowing (30 June) which was significantly superior to remaining date of sowing at harvesting stage.

The increase in periodic dry matter accumulation with application of integrated nutrient management may be attributed to increased plant height and leaf-area index, thereby resulting in better light interception by crop which accumulated more photosynthates and thus produced more dry matter. Further, FYM and pressmud supplied the nutrients in balanced proportion and improved the physical characters, which might have increased the availability of nutrients. These results are in line with those of Bairwa *et al.* (2013).

Among all the dates of sowing, 30 June (D_2) was found to be superior to the other sowing dates regarding dry-matter production which might be owing to congenial weather condition like optimum amount and uniform distribution of rainfall and favourable temperature prevailed during the vegetative period of pearl millet crop which helped in improvement of dry matter production. Our results confirm the findings of Dalvi (2005); Maurya *et al*. (2016).

Yield attributes

The ear length recorded with the application of 100% RDF + pressmud @ 2.5 t/ha was significantly maximum, followed by 100% RDF + FYM @ 5 t/ha (M_2) significantly minimum with 100% RDF only (Table 2). Among the dates of sowing, the treatment raised on June 30 produced significantly maximum ear length, followed by the 15 July and 15 June. The treatment D_4, i.e. 30 July recorded the minimum ear.

An analysis of the pooled mean data (Table 2) showed that grain weight/ear was higher with 100% RDF + pressmud @ 2.5 t/ha (M_3). Moreover, the trend of treatment was just in the same line as that of the first as well as second year results. The data from pooled mean of both the years revealed that, significantly more grain weight/ear was noted when sowing was done on 30 June as compared to the other sowing dates.

The pooled mean data (Table 2) of the both the years

Table 2. Effect of integrated nutrient management and dates of sowing on yield attributes of pearl millet (pooled over 2014 and 2015)

Treatment	Ear length (cm)	Weight of grain ear (g)	1,000-grain weight (g)
Integrated nutrient management			
M_1, 100% RDF	19.6	12.1	4.8
M_2, 100% RDF + FYM @ 5 t/ha	21.9	13.8	5.9
M_3, 100% RDF + Pressmud @ 2.5 t/ha	24.2	14.0	6.8
SEm±	0.5	5.8	0.1
CD (P=0.05)	1.7	0.8	0.4
Dates of sowing			
D_1, 15 June	20.8	13.7	5.2
D_2, 30 June	26.0	16.2	7.2
D_3, 15 July	23.6	15.0	6.6
D_4, 30 July	17.2	12.2	4.4
SEm±	0.5	0.5	0.1
CD (P=0.05)	1.7	1.2	0.4

RDF, Recommended dose of fertilizer

showed the values of test weight varied from 6.8 to 4.8, the maximum being achieved with M_3 treatment (100 % RDF + pressmud @ 2.5 t/ha), followed by M_2 and M_1. Among the dates of sowing, test weight was higher when pearl millet crop was sown on 30 June followed by D_3, D_1 and D_4 treatments.

The ear length, weight of grain/ear and 1,000-grain weight of the pearl millet was not influenced significantly due to interaction between effect of main and subtreatments.

The beneficial effect of yield attributes might also be owing to the supply of all the essential nutrients by pressmud and FYM that might have resulted in higher manufacture of food and its subsequent partitioning of photosynthates towards sink. These findings was similar to those of Khan *et al*. (2000) and Kumar and Gautam (2004).

Sowing of pearl millet at optimum date of sowing 30 June had shown significantly better development of source in form of dry-matter accumulation, which contributed to the higher grain weight. Our results support the findings of Prashanth (2013).

Grain and straw yield

On the basis of pooled (Table 3), significantly higher grain yield of pearl millet (3,165 kg/ha), straw yield (4,913 kg/ha) and harvest index (38%) were recorded with the M_3 treatment, consisting of the combination of 100% RDF + pressmud @ 2.5 t/ha. The next best treatment was M_2 (100% RDF + FYM @ 5 t/ha). Significantly lower grain yield, straw yield and harvest index (36.4%) were noticed under the sole inorganic treatment of 100% RDF (M_1). Among various dates of sowing, 30-June sowing (3,242 kg/ha) resulted in higher grain yield, straw yield (5,360 kg/ha) and harvest index (38.1%) than the other dates of sowing.

The interaction effect of integrated nutrient management and sowing dates were not statistically significant during both the years.

Balanced supply of nutrients through inorganic fertilizers coupled with organic manures resulting higher biomass, seed yields, partitioning of dry matter between grain and other plant parts finally led to higher harvest index. Our results confirm by Patil *et al*. (2006).

Optimum utilization of solar radiation, temperature, higher assimilates production and its conversion to starch results in higher biomass, seed yield leading to higher harvest index. These observations corroborate with those of Dera *et al*. (2014).

Nutrient uptake at harvest (kg/ha)

Nitrogen uptake

Nitrogen uptake in grain and in straw was significantly higher with 100% RDF + pressmud @ 2.5 t/ha and 100 % RDF + FYM @ 5 t/ha during both the year. The minimum uptake in and straw was observed under treatment 100% RDF alone. Among the dates of sowing, pearl millet crop when raised on 30 June exhibited significantly highest nitrogen uptake in grain and straw followed by the treatment D_3, D_1 and D_4 (Table 4).

Phosphorus uptake

Significantly highest phosphorus uptake in grain and straw was recorded with 100% RDF + pressmud @ 2.5 t/ha, followed by M_2 and M_1 as observed from the pooled data (Table 4). Among various dates of sowing 30 June exhibited maximum P uptake.

Table 3. Effect of integrated nutrient management and dates of sowing on grain and straw yield (kg/ha) and harvest index (%) of pearl millet (pooled over 2014 and 2015)

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	HI (%)
Integrated nutrient management			
M_1,100% RDF	2,096	3,783	36.4
M_2,100% RDF + FYM @ 5 t/ha	2,594	4,772	37.0
M_3,100% RDF + Pressmud @ 2.5 t/ha	3,165	4,913	38.0
SEm±	96	1,707	1.1
CD (P=0.05)	377	331	NS
Sub treatments (Dates of Sowing)			
D_1, 15 June	2,401	4,133	36.8
D_2, 30 June	3,242	5,360	38.1
D_3, 15 July	2,872	4,817	37.6
D_4, 30 July	1,957	3,413	36.2
SEm±	102	152	1.2
CD (P=0.05)	354	524	NS

RDF, Recommended dose of fertilizer

Potassium uptake

Significantly higher potassium uptake in grain and in straw was observed in the M_3 treatment (Table 4). Among the dates of sowing, pearl millet crop sown on 30 June showed the highest potassium uptake in grain and straw, followed by D_3, D_1 and D_4 treatments.

Interaction effect of integrated nutrient management and dates of sowing were found to be non-significant with the respect to nutrient uptake of the crop.

The response of crops to integrated nutrient management was due to higher availability of these nutrients in soil reservoir besides the additional quantity of nutrients supplied by press mud, FYM and inorganic fertilizers. These results corroborate the findings of Jadav *et al*. (2011).

Optimum time of sowing and favourable weather conditions might have led to proportionate increase in growth parameters like dry-matter production, leaf-area index and number of tillers/plant resulting in more nutrient concentration and nutrient availability in the root zone. Hence higher nutrient content in the produce and higher biomass production of crop might be the pertinent reason for higher uptake of nutrients (N, P and K) by seed and stalk. These results are accordance with the findings of Deshmukh *et al*. (2013).

Economics

Analysis of the pooled mean data (Table 5) showed that significantly higher gross returns (39,965 ₹/ha), net returns (17,903₹/ha) and benefit: cost ratio (1.81) were recorded with 100% RDF + pressmud @ 2.5 t/ha, followed by M_2

Table 4. Effect of integrated nutrient management and dates of sowing on nutrient uptake (kg/ha) of pearl millet at harvest (pooled over 2014 and 2015)

Treatment	Nitrogen uptake(kg/ha)		Phosphorus uptake (kg /ha)		Potassium uptake (kg/ha)	
	Grain	Straw	Grain	Straw	Grain	Straw
Integrated nutrient management						
M_1,100% RDF	22.6	38.8	6.2	9.6	21.3	39.8
M_2,100% RDF + FYM @ 5 t/ha	27.4	46.8	7.4	12.3	25.4	47.9
M_3,100% RDF + Pressmud @ 2.5 t/ha	31.7	53.3	8.4	14.4	28.8	55.0
SEm±	0.8	1.3	0.2	0.3	0.8	1.2
CD (P=0.05)	2.7	5.1	0.6	1.3	2.6	4.7
Dates of sowing						
D_1, 15 June	25.2	42.6	6.3	10.3	23.2	43.8
D_2, 30 June	35.1	59.1	9.8	16.2	31.1	59.0
D_3, 15 July	28.9	49.6	8.2	13.7	27.5	52.2
D_4, 30 July	19.7	33.9	5.1	8.1	18.8	33.2
SEm±	1.0	1.7	0.3	0.6	0.8	1.7
CD (P=0.05)	3.5	5.6	1.0	1.9	2.4	5.4

RDF, Recommended dose of fertilizer

Table 5. Effect of integrated nutrient management and dates of sowing on economics of pearl millet (pooled over 2014 and 2015)

Treatment	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	Benefit: cost ratio
Integrated nutrient management				
M_1,100% RDF	15,812	26,478	10,666	1.68
M_2,100% RDF + FYM @ 5 t/ha	18,312	32,753	14,441	1.79
M_3,100% RDF + Pressmud @ 2.5 t/ha	22,062	39,965	17,903	1.81
SEm±	-	1,099	758	0.04
CD (P=0.05)	-	4,316	2,975	0.13
Sub treatments (Dates of Sowing)				
D_1, 15 June	18,728	30,318	11,590	1.62
D_2, 30 June	18,728	40,959	22,231	2.19
D_3, 15 July	18,728	36,276	17,548	1.94
D_4, 30 July	18,728	24,708	5,980	1.30
SEm±	-	1,243	934	0.08
CD (P=0.05)	-	4,302	3,232	0.20

RDF, Recommended dose of fertilizer

and M_1. Across the 4 dates of sowing 30 June sowing of pear millet resulted in significantly higher gross returns (40,959₹/ha), net returns (22,231₹/ha) and benefit: cost ratio (2.19) than the other sowing dates.

It was concluded that the application of 100% RDF + pressmud @ 2.5 t/ha may produce the higher grain yield and net returns of pearl millet when sowing was done on 30 June rather than 15 June and 15 July and 30 July.

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