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Effect of Seedlings Age and Nutrient Combinations on Growth and Yield of Proso Millet (*Panicum miliaceum* L.) in Lateritic Soils of Western Ghats

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ABSTRACT

Background: Proso millet (*Panicum miliaceum* L.) was considered a self-pollinated annual crop that belongs to the family Poaceae. It was well adapted to many soil and climatic conditions. The productivity was low due to the use of poor quality seed, little or no use of fertilizers, traditional methods of cultivation, delay in nursery sowing and late transplanting. The Integrated Nutrient Supply System (INSS) approach involves the combined use of chemical fertilizers, organic manures and micronutrient fertilizers, which ensures higher crop productions and also helps to restore and sustain soil fertility. Therefore, the study was focused to manage the timely transplanting together with the suitable nutrient combination.

Methods: A field experiment was conducted to study the "Effect of seedlings age and different nutrient combinations on growth and yield of Proso Millet (*Panicum miliaceum* L.) in lateritic soils of Western Ghats" during *Kharif*, 2016. The experiment was laid out in a split-plot design with four main plots and five subplot treatments. The main plot treatments composed of four ages of seedlings *viz*. 20, 30, 40 and 50 days and five subplot treatments of nutrient combinations *viz*., 100% RDF, 75% RDF + 25% N through FYM, 50% RDF + 50% N through FYM, 25% RDF + 75% N through FYM and 100% N through FYM. Thus, there were twenty treatment combinations, replicated thrice.

Result: Results revealed that the proso millet crop transplanted with 30 days old seedlings recorded significantly higher grain yield and straw yield over all other treatments. In nutrient combinations treatments, 100% RDF through chemical fertilizer recorded significantly higher mean plant height hill^{-1}, number of functional leaves hill^{-1}, number of functional tillers hill^{-1} and plant dry matter accumulation hill^{-1} than the other treatments and also produced significantly highest yields and yield attributing characters compared to the rest of the nutrient combinations.

Key words: FYM, Growth, Proso millet, RDF, Seedlings age, Yield.

INTRODUCTION

Proso millet (*Panicum miliaceum* L.) is considered a self-pollinated annual crop that belongs to the family Poaceae. It is well adapted to many soil and climatic conditions. It is found high in mountains; in the former USSR up to 1200 m and in India up to 3500 m. It requires very little water, possibly the lowest water requirement of any cereal and converts water most efficiently to dry matter per plant. This is because of its short growing season.

It is mainly cultivated for human consumption in Eastern and Central Asia and to a lesser extent in Eastern Europe (Russia, Danube region) and from Western Asia to Pakistan and India (Bihar, Andhra Pradesh, Maharashtra, *etc*). In India, it is cultivated over an area of 0.07 million ha with a total production of 0.43 million tonnes, (Anonymous, 2013) with two-thirds share of the total recorded millet trade. Uttar Pradesh, Madhya Pradesh, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu are the main states of its cultivation in India. In India, small millet was cultivated over an area of 9.03 lakh ha with a total production of 4.45 lakh tonnes during 2014-15 (Kate, 2016).

It is cultivated by transplanting in the *Konkan* region. To get higher yields, the age of the optimum seedlings should be adopted with proper nutrient combinations. The productivity is low due to the use of the poor quality seed, little or no use of fertilizers, traditional methods of cultivation, delay in nursery sowing and late transplanting. To boost its yields, timely transplanting and properly fertilizing the crop is necessary. At the time of transplanting, availability of laborers is a main constraint in the *Konkan* region.

Integrated Nutrient Supply System (INSS) approach involves the combined use of chemical fertilizers, organic manures and micronutrient fertilizers, which ensures higher

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crop productions and also helps to restore and sustain the soil fertility (Kadrekar, 1993). Fertilizers and manures play an important role in increasing productivity and improving the quality of cereals. Organic manures including FYM, compost, poultry manure and vermicompost contain all the nutrients required for the healthy growth of crops. They improve soil structure and aeration of the soil. They help in increasing the nutrient availability from the soil and applied sources (Halkatti *et al.,* 1997).

MATERIALS AND METHODS

The field experiment was conducted at the Agronomy farm, College of Agriculture, Dapoli, District Ratnagiri (M.S.) during the *Kharif*, 2016-17. The soil of the experimental plot was sandy clay loam in texture, moderately acidic in pH and very high in organic carbon content. It was low in available nitrogen, low in available phosphorus and moderately high in available potassium. The field experiment was laid out in a split-plot design. The main plot comprised of four ages of seedlings *i.e*., A1-20, A2-30, A3-40 and A4-50 days old seedlings and subplot treatment consisted of five nutrient combinations, N1-100% RDF, N2-75% RDF + 25% N through FYM, N3-50% RDF + 50% N through FYM, N4-25% RDF + 75% N through FYM and 100% N through FYM and N5-100% N through FYM. Thus, there were 20 treatment combinations of replicated thrice. Proso millet nursery was manured with FYM @ 250 kg 100^{-2} area and it was mixed thoroughly in the soil at the time of seedbed preparation. Then nursery bed of 3 m × 1 m size was prepared in a well-tilled plot. Fertilizers *viz*., urea and single super phosphate @ 1 kg and 3 kg 100 m^{-2}, respectively were used at the time of sowing. The fungicide treated seeds were sown on the raised beds in lines at 10 cm apart and 2.5 cm depth on different sowing times across the length of the raised beds. The seed was sown shallow and thin. After sowing, the seed was covered with soil. A hand weeding of the nursery was done at 15 days after sowing (DAS) and it was top-dressed with urea @ 0.5 kg 100 m^{-2} after hand weeding. The gross plot size 4.2 m × 3.0 m and the net plot size 3.8 m × 2.7 m. The seedbed for proso millet was prepared by ploughing the land with a tractor-drawn plough, followed by a tractor-drawn rotavator for clod crushing, planking was done to bring the field into a level and fine tilth. Transplanting of proso millet was done when the ages of seedlings were 20, 30, 40 and 50 days old, respectively. The transplanting two seedlings $hill^{-1}$ was transplanted at 20 cm × 15 cm spacing. Seedlings were transplanted by the locally used "thomba" method. The crop was manured and fertilized as per the treatments according to the recommended dose of proso millet. FYM @ 5 t ha^{-1} was applied and incorporated before the last preparatory tillage operation. The recommended dose of fertilizer (RDF) used for proso millet was 80:40:0 kg NPK ha^{-1}. Nitrogen was applied in the form of urea and phosphorus was applied through single super phosphate. Harvesting of the experimental crop was carried out when 85 percent of grains in the panicles were matured to avoid shading of grains. Net plot area was harvested after removing ring lines and observation plants. The threshed product was winnowed immediately and then the grain and straw weights were recorded. The data related to each character of the crop was analyzed statistically by using the standard method of 'Analysis of Variance'.

RESULTS AND DISCUSSION

Effect of seedling age on growth and yield

It was evident from the data presented in Table 1 that a remarkable influence of various seedlings age on the growth characters of the crop was observed during the entire growth stages. It showed significant variation in the growth and development parameters *viz.,* plant height $hill^{-1}$, number of functional leaves $hill^{-1}$, number of functional tillers $hill^{-1}$ and dry matter accumulation $hill^{-1}$ due to the age of seedlings. The height of the plant increased with the advancement in the age of the crop and maximum height (162.67 cm) was observed in the treatment A_2. The maximum height was recorded at 30 DAT. This increase in the plant height of seedlings transplanted at 40 and 50 days age remained visible till 30 DAT. A_1 reported minimum growth attributes, which may be due to reduced photosynthesis mainly due to no sunshine hours after transplanting and inhibition of photosynthesis reaction (Amin and Haque, 2009) and Chavan, 1995). More number of leaves were recorded with A_2. Proper seedling's age helped to take advantage of nutrients, moisture and environmental factors. Transplanting of A_2 produced a higher number of leaves (7.41) (Amin and Haque 2009). The mean value of the table revealed that transplanting of A_2 responded well and recorded a significantly higher number of tillers $hill^{-1}$ (3.87) over others. Tiller production reduced significantly with an increase in the age of the seedlings beyond 30 days at all the stages of crop growth. The tillering period was also extended up to 50 days and it was observed that seedlings (A_3 and A_4) responded well and reached maximum level up to 90 DAT whereas, transplanting of overaged or underaged seedlings (A_1 or A_4), there were declining trends in the number of tillers due to death or non-functional tillers. The tillering dynamics of the proso millet plant greatly dependant on the age of the seedlings at transplanting. The reason for higher tillering ability with the young seedlings might be due to the completion of more number of *phyllochrons* during the vegetative phase compared to older seedlings and when a seedling was transplanted carefully at the initial growth stage, the trauma of root damage caused during uprooting was minimized (Amin and Haque 2009 and Sarker 2012). In general, the dry matter accumulation increased with the advancement of crop age under all the treatments and it was maximum at the ripening stage. Transplanting of A_2 recorded significantly highest dry matter production at all the stages of crop growth as compared to that of other aged seedlings transplanted. The lowest dry matter production, particularly

Table 1: Effect of different treatment on growth attributes of proso millet.

Treatment	Plant height (cm)				No. of functional leaves hill^{-1}				No. of functional tillers hill^{-1}				Dry matter hill^{-1} (g)			
	30	60	90	Harvest	30	60	90	Harvest	30	60	90	Harvest	30	60	90	Harvest
A_1	20.59	143.24	152.45	157.52	17.01	40.00	6.86	6.62	3.20	3.23	3.25	3.21	6.09	19.67	29.46	29.67
A_2	25.65	144.37	157.68	162.67	17.46	40.31	7.63	7.41	3.68	3.88	3.88	3.87	7.45	22.21	33.77	33.83
A_3	24.10	141.73	156.29	161.34	17.10	38.79	5.45	5.41	3.47	3.53	3.59	3.56	6.38	21.15	31.61	31.73
A_4	22.28	140.25	149.05	154.07	16.61	38.08	5.44	5.40	3.33	3.40	3.40	3.32	6.24	19.92	30.25	30.35
F. test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	N.S	Sig	Sig	Sig	Sig	Sig	Sig	Sig
S. Em. ±	0.18	0.44	0.30	0.35	0.07	0.12	0.08	0.13	0.14	0.04	0.05	0.03	0.07	0.11	0.26	0.28
C.D. at 5%	0.64	1.53	1.04	1.22	0.24	0.43	0.29	0.45	0.50	0.14	0.17	0.10	0.24	0.38	0.92	0.98
Nutrient combinations																
N_1	25.18	145.64	156.60	161.64	17.72	40.53	7.15	7.02	3.88	4.07	4.08	4.05	7.59	23.74	34.10	34.36
N_2	24.00	143.76	155.23	160.27	17.41	39.98	6.78	6.65	3.67	3.80	3.83	3.80	7.06	22.33	32.54	32.66
N_3	23.55	142.34	153.71	158.68	17.11	39.40	6.32	6.15	3.53	3.47	3.48	3.43	6.51	20.94	31.48	31.56
N_4	22.19	141.13	152.52	157.55	16.82	38.85	5.90	5.74	3.15	3.27	3.27	3.23	6.07	19.36	29.71	29.78
N_5	20.87	139.10	151.29	156.36	16.16	37.70	5.58	5.50	2.87	2.95	2.98	2.93	5.48	17.33	28.53	28.63
F. test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
S.Em. ±	0.27	0.39	0.38	0.39	0.10	0.15	0.08	0.10	0.14	0.06	0.05	0.10	0.08	0.14	0.23	0.20
C.D. at 5%	0.78	1.12	1.09	1.12	0.30	0.45	0.23	0.28	0.40	0.18	0.14	0.28	0.24	0.40	0.66	0.59
Interaction effect																
F. test	N.S.	N.S.	N.S.	N.S.	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
S.Em. ±	0.54	0.77	0.76	0.78	0.21	0.31	0.16	0.20	0.28	0.12	0.10	0.19	0.16	0.28	0.46	0.41
General mean	23.16	142.40	153.87	158.90	17.04	39.29	6.35	6.21	3.42	3.51	3.53	3.49	6.54	20.74	31.27	31.40

cm: Centimetre (s); No: Numbers; hill^{-1}: Per hill; g: Gram; A_1 : 20 days old seedlings; A_2 : 30 days old seedlings; A_3 : 40 days old seedlings; A_4 : 50 days old seedlings; N_1 : 100% RDF; N_2 : 75% RDF + 25% N through FYM; N_3 : 50% RDF + 50% N through FYM; N_4 : 25% RDF + 75% N through FYM; N_5 : 100% N through FYM.

with older seedlings at all stages, might be because the seedlings spent the greater part of their vegetative phase in the nursery itself were no proper space for proper development, shoot growth, lack of water, nutrients and as well as solar radiation also for individual seedling resulted in poor production of carbohydrates (Rasool *et al.,* 2016). Further it was indicated that the plant vigor was affected due to variation in the age of the seedlings at transplanting. In other words, the different physiological processes were influenced due to variation in the age of the seedlings at transplanting. Therefore, the entire yield attributes *viz.,* number of panicles hill^{-1}, length of panicle, the weight of a panicle, number of rachis panicle^{-1} and test weight (Table 2) were influenced due to variation in the age of the seedlings of proso millet crop at transplanting. It indicates that among the different ages of seedlings, the crop planted with A_2 recorded significantly more number of panicles hill^{-1} as compared to others. When aged seedlings of 40 and 50 days old were used for transplanting by the time the crop received fertilizer, the crop had crossed the maximum tillering phase and the late formed tillers had resulted only in non-functional tillers leading to a drastic reduction in the percent productive tillers (Naresh, 2012). Significantly maximum panicle length was recorded with the planting of A_2. It must be due to the proper availability of nutrients at A_2 and the high net assimilation rate. (Amin and Haque, 2009). The significantly maximum weight of panicle hill^{-1} was recorded with the planting of A_2. It was clear from the table that planting of early age seedling produced maximum weight panicle^{-1} over aged seedling might be due to fact that planting of early age seedlings in the main field gets more opportunity to harness solar radiation for photosynthesis and established better source and sink relationship which turns in the highest weight of panicle^{-1} (Amin and Haque, 2009). The increased number of rachis panicle^{-1} recorded from A_2 used might be due to proper crop growth rate and maximum crop net assimilation rate as compared to the older seedlings followed by the attainment of physiological growth, particularly panicle initiation, flowering and asynchronous tillering (Amin and Haque, 2009). The highest test weight was recorded with the planting of early aged seedlings *i.e*., A_2 which was at par with A_3. Test weight was an important yield contributor that depends on genetic makeup and was affected by growing conditions, seedlings age as well as other managemental factors (Amin and Haque, 2009).

The mean value of the table reveals that in general with successive advancements in the age of the seedlings from 30 to 50 days succeeding 20 days, the grain yield decreased significantly. Among different ages of seedlings, the crop planted with A_2 recorded higher grain yield. Delayed planting had a significantly reduced grain yield. The higher grain yield (14.17 q ha^{-1}) obtained with A_2 was due to higher dry matter production, more number of

Table 2: Effect of different treatment on yield attributes and yield (q ha^{-1}) of proso millet.

Treatment	No. of panicles hill^{-1}	Length of panicle (cm)	Weight of panicle (g)	No. of rachwas panicle^{-1}	Test weight (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest Index
A_1	3.17	34.03	8.41	17.77	1.60	8.90	21.07	30.09
A_2	3.85	36.41	8.48	18.63	1.65	14.17	32.30	30.70
A_3	3.56	35.47	7.99	17.88	1.63	12.27	29.56	29.34
A_4	3.27	35.57	7.89	17.60	1.58	10.65	25.37	29.41
F. test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	N.S
S. Em. ±	0.06	0.23	0.10	0.05	0.01	0.21	0.36	0.57
C.D. at 5%	0.22	0.79	0.33	0.18	0.03	0.71	1.25	1.97
Nutrient combinations								
N_1	4.05	37.44	9.01	18.78	1.65	12.48	29.80	29.51
N_2	3.75	36.67	8.69	18.33	1.64	12.01	28.44	29.66
N_3	3.42	34.86	8.25	17.89	1.62	11.65	27.44	29.75
N_4	3.20	34.33	7.92	17.52	1.60	11.18	26.46	29.68
N_5	2.90	33.55	7.09	17.33	1.56	10.15	23.23	30.84
F. test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	N.S
S.Em. ±	0.06	0.21	0.12	0.08	0.01	0.22	0.59	0.98
C.D. at 5%	0.18	0.60	0.35	0.22	0.04	0.65	1.70	2.82
Interaction effect								
F. test	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
S.Em. ±	0.12	0.42	0.24	0.15	0.03	0.45	1.18	1.96
General mean	3.46	35.37	8.19	17.97	1.61	11.50	27.07	29.89

cm: Centimetre (s); No: Numbers; hill^{-1}: Per hill; panicle^{-1}: Per panicle; q ha^{-1}: Quantal per hectare; g: Gram; A_1 : 20 days old seedlings; A_2 : 30 days old seedlings; A_3 : 40 days old seedlings; A_4 : 50 days old seedlings; N_1 : 100% RDF; N_2 : 75% RDF + 25% N through FYM; N_3 : 50% RDF + 50% N through FYM; N_4 : 25% RDF + 75% N through FYM; N_5 : 100% N through FYM.

panicles hill^{-1} as compared to others. Better translocation of nutrients from source to sink due to planting in A_2 as compared to others might have contributed to better grain yield. In general grain yield was directly related to the duration of a variety and its genetic makeup. The straw yield decreased linearly with the successive advancement in the age of the seedlings from 30 to 50 days succeeding 20 days. The higher straw yield (32.30 q ha^{-1}) obtained with A_2 was mainly attributed to more plant height, a higher number of tillers hill^{-1}, panicles hill^{-2} and dry matter production at harvest compared to other three ages of seedlings (Mohapatra, 1989); Kumar *et al.,* 2008 and Barla *et al.,* 2013). The harvest index was not significantly influenced by the age of the seedlings. However, among different ages of seedlings, the crop planted with A_2 recorded maximum harvest index compared to other seedling's age (Mohapatra, 1989 and Sarker, 2012).

Effect of nutrient combinations on growth and yield

It was observed from Table 1 that the plant height gave significant responses to the application of different nutrient combinations at all the growth stages of the crop under study. Application of N_1 recorded maximum plant height. The plant height increased significantly throughout the growth period up to 90 DAT; thereafter, there were no much changes in height up to harvest. It was generally identified that nutrients in ample quantities increase plant growth by cell elongation and cell division, both in terms of enhancing cell multiplication thereby increasing the plant height (Kumar *et al.,* 2008 and Banerjee and Pal, 2011). Application of N_1 recorded significantly more number of leaves hill^{-1} due to the faster availability of nutrients from the fertilizers. The higher rate and easy availability of nutrients favored the increase in the number of leaves. The mean number of functional tillers hill^{-1} (Table 1), a significant response to nutrient fertilization was observed at all the stages of crop growth. Application of N_1 recorded a significantly higher number of functional tillers hill^{-1} at all the growth stages except at 30 DAT. It might be due to the rapid availability of nutrients through chemical fertilizers helped to gain more number tillers (Singh, 1999 and Singh *et al.,* 2015). The dry matter accumulation in proso millet crops significantly increased from 30 DAT up to harvest as nitrogen levels. At the initial stage, the rate of dry matter production was rather slow. However, at 60 DAT and onwards the crop entered into a phase of a rapid rate of dry matter production and at the final stage, it lowered to some extent, following the sigmoid growth curve. This might be due to N_1 application which helped in synthesizing more photosynthates resulting in higher dry matter accumulation (Kumar *et al.,* 2008 and Banerjee and Pal, 2011).

The number of panicles hill^{-1} was significantly higher in the treatment of N_1. Generally, higher nutrients influenced the number of tillers hill^{-1} and it ultimately reflected into increased panicle number in proso millet crop (Singh 1999, Kumara, 2007 and Banerjee and Pal, 2011). Application of N_1 recorded significantly higher panicle length (Singh 1999, Kumara, 2007 and Chouhan *et al.,* 2015). The data on the number weight of panicle hill^{-1} revealed that significantly maximum weight of panicle hill^{-1} was recorded with the planting of N_1. It was quite clear from data given in Table 2 that due to fact the application of the recommended dose in the main field help to carry out photosynthesis and established a better source and sink relationship which turns in the highest weight of panicle^{-1} (Singh, 1999 and Kumara, 2007). The increased number of rachis panicle^{-1} recorded under N_1 might be due to proper crop growth rate and maximum crop net assimilation rate followed by the attainment of physiological growth, particularly panicle initiation, flowering and asynchronous tillering (Singh, 1999). The effect of different treatments on test weight was presented in Table 1 which revealed that N_1 recorded the highest value. Test weight was an important yield contributor that depends on genetic makeup and was affected by growing conditions, nutrient management as well as other managemental factors (Banerjee and Pal, 2011 and Gour *et al.,* 2015). The maximum grain yield (12.48 q ha^{-1}) in N_1 was due to the combined effect of more number of tillers, more number of panicles and more number rachis panicle^{-1} (Nigade and More, 2013, Singh *et al.,* 2015; Gour *et al.,* 2015 and Pradhan *et al.,* 2016). The data in respect of straw yield at harvest indicated that the straw yield of proso millet was significantly influenced due to nutrient combinations. Application of N_1 produced significantly higher straw yield (29.80 q ha^{-1}) .This might be because the different combinations of nutrients influenced the physiological activity of the dry matter accumulation also increased with the nutrient application and it was optimum at the maturity stage due to diversion of food material from source to sink (Kumar *et al.,* 2008, Nigade and More, 2013 and Singh *et al.,* 2015).

Interaction effect

The interaction effect of seedling's age and nutrient combinations was found to be non-significant in respect to all the characters studied.

CONCLUSION

The results of this study indicated that 30 days old seedlings should be used for transplanting along with the application of 100 percent RDF through chemical fertilizers to obtain higher growth and yield from proso millet.

Conflict of interest

All authors declare that they have no conflict of interest.

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