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Effect of different levels of fertilizer and plant spacing on growth of taro (*Colocasia esculenta* L.) genotype under Marathwada conditions

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Abstract
The present experiment was carried out during the year 2023-2024. The experiment was laid out in Factorial Randomized Block Design with three replications. All the plant growth characters were taken at 30, 60, 90 and 120 days after planting (DAP). Three levels of fertilizer dose *viz.*, F_1[100% recommended dose of NPK (80:60:60 kg/ha), F_2 [125% of recommended dose of NPK (100:75:75 kg/ha), F_3 [75% of recommended dose of NPK (60:45:45 kg/ha) and three levels of plant spacing *viz.*, S_1 (60 cm x 45 cm), S_2 (60 cm x 60 cm), S_3 (60 cm x 30 cm) were used as treatment variables. The growth attributes of taro *viz.*, Days to sprouting (5.27), percent sprouting (100%), days to first leaf emergence (6.24), plant height (86.70 cm), number of leaves per plant (6.30), number of suckers per plant (7.64), leaf area (647.60 cm^2), petiole length (79.90 cm) at 120 DAP respectively was found significantly superior in treatment combination F_2S_2 [125% of RDF (100:75:75 kg/ha at 60 x 60 cm spacing) than rest of the treatment combinations under study.

Keywords: Fertilizer, growth, spacing, taro

Introduction
Taro (*Colocasia esculenta* L.) is a highly nutritious crop, particularly valued for its corms, which contain 63-85% water and are rich in essential nutrients. These corms provide 1.3-4.0% protein, 13-29% carbohydrates, 0.6-1.2% fiber and 2.0-4.0% fat with the starch content ranging between 13-30%. Notably, taro has higher protein content than yam, cassava, and sweet potato, making it a valuable protein source despite its relatively low fat content. The quality of taro corms and cormels is influenced by their acridity and fiber content, and the small size of their starch granules contributes to their excellent digestibility, with an estimated digestibility rate of 98.9%. It is also rich in potassium, calcium, phosphorus, iron, riboflavin, thiamine, niacin, vitamins A and C along with dietary fiber.
Taro is also a good source of essential amino acids like leucine and phenylalanine. Furthermore, all parts of the taro plant, including the corms, cormels, rhizomes, petioles, leaves, and flowers are edible and contain significant nutritional value. Even after boiling, the tender petioles and leaves remain a rich source of iron and vitamin C, making taro an excellent food for a variety of dietary needs.
Two main determining variables for any crop's optimum growth and production are nutrient management and spacing. To increase growth and yield, wise and appropriate application of fertilizers and spacing is necessary. While too high or too low plant spacing can lead to relatively low yield and quality, appropriate plant spacing can produce the best potential production (Akther *et al.*, 2016) [1]. In view of this, the present investigation was conducted to find out optimum dose of fertilizer and appropriate spacing for obtaining vigorous growth in taro.

Methodology
The present investigation was conducted on the instructional cum research farm of College of Horticulture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (Maharashtra), during the year 2023-2024.The experiment was set up in a Factorial Randomized Block Design (FRBD) with three treatments replicated thrice with 09 treatment combinations. Twenty-one distinct taro genotypes were evaluated in previous year among which PBNT-1

genotype was found best in respect to quantitative and qualitative parameter under Marathwada conditions hence, the said selected genotype was used in the present investigation for estimation of optimum dose of fertilizer and spacing. Subsequently the Uniform sized healthy, disease free corms weighing 30-40 g were used for planting at three different spacings *viz.*, S_1= 60 x 45 cm S_2= 60 x 60 cm S_3= 60 x 30 cm with the application of different levels of fertilizers *viz.*, F_1= 80:60:60 kg NPK/ha (100% RDF) F_2=100:75:75 kg NPK/ha (125% RDF) F_3= 60:45:45 kg NPK/ha (75% RDF). The other cultivation practices were followed as per recommendations and observations of various growth parameters were recorded periodically and data was statistically analyzed as per standard methods.

Results and Discussion

The data pertaining to days to sprouting, percent sprouting and days to first leaf emergence under various treatments have been statistically analyzed and presented in Table 1. The least number of days for sprouting (6.99 days) was recorded in F_2 [125% of recommended dose of NPK (100:75:75 kg/ha)], which was considerably superior among rest of the treatments, whereas the maximum number of days for sprouting (12.10 days) were recorded in F_3 [75% of recommended dose of NPK (60:45:45 kg/ha)]. The minimum number of days to sprouting (7.44 days) was recorded in the plant spacing of S_2 (60 cm x 60 cm) while S_3 (60 cm x 30 cm) recorded maximum number of days to sprouting (10.38 days). The interaction between different levels of fertilizer and plant spacing had a significant effect on the number of days to sprouting. The shortest sprouting time was observed in the F_2S_2 combination recording (5.27 days), which was significantly superior among all other treatment combinations.

This might be due to application of higher level of fertilizer fulfill the nutritional requirement which promotes early sprouting. Nutrients like NPK enhance soil fertility and corms vigor, thereby improving sprouting conditions similarly, plant spacing can influence the days to sprouting primarily by affecting soil conditions and resource availability. Adequate spacing ensures that corms have enough room to access light, water and nutrients, which can promote even and timely sprouting. Crowded conditions may lead to competition for these resources, potentially delaying sprouting or causing uneven growth. Proper spacing helps optimize conditions for each corm, potentially leading to early and more uniform sprouting (Sagoe *et al.* 2018) [8].

The highest sprouting rate (100%) was achieved in F_2 [125% of recommended dose of NPK (100:75:75 kg/ha). This was significantly superior among rest of the treatments and the lowest sprouting (88.18%) was obtained in F_3 [(75% of recommended NPK dose (60:45:45 kg/ha)]. Proper fertilization can enhance germination rates, as phosphorus, for example, is crucial for root development. However, over fertilization can harm seeds by increasing soil salinity, while insufficient fertilization might limit growth. Additionally, soil conditions and the specific nutrient needs of different seeds play a role in how effectively fertilizers influence sprouting. The plant spacing of S_2 (60 cm x 60 cm) had the highest sprouting (94%) while S_3 (60 cm x 30 cm) recorded lowest sprouting (92.93%). Plant spacing can impact the percent sprouting of tubers, though its effects are often more pronounced during the later stages of plant growth. Proper spacing allows each seedling to access adequate light, nutrients and water, which can promote healthy growth and better establishment. Conversely, overcrowding can lead to competition for resources, potentially reducing sprouting rates and overall plant health. Similar results were reported by Khandekar *et al.* (2000) [4] and Ndon *et al.* (2003) [6] in taro. The interaction of different levels of fertilizer and plant spacing was showed non-significant effect on percent sprouting.

The minimum days to first leaf emergence (8.35 days) was recorded in F_2 [125% of recommended dose of NPK (100:75:75 kg/ha)] which was significantly superior over rest of the treatments and treatment F_3 [(75% of recommended dose of NPK (60:45:45 kg/ha)] took maximum days (16.93 days) to first leaf emergence. In respect to the plant spacing, treatment S_2 (60 cm x 60 cm) recorded minimum days (11.14 days) to first leaf emergence however, S_3 (60 cm x 30 cm) took maximum days to first leaf emergence (14.02 days). Application of optimum fertilizer dose and appropriate plant spacing leads to quicker and more uniform leaf emergence by optimizing the plant's growth environment (Shellikeri *et al.* 2019) [9]. The interaction of plant spacing and fertility levels was showed non- significant effect on days to first leaf emergence.

Table 1: Effect of fertilizer, plant spacing levels and their interaction on days to sprouting, percent sprouting (%) and days to first leaf emergence

Treatments	Days to sprouting	Percent sprouting (%)	Days to first leaf emergence
Fertilizer levels			
F_1	7.74	92.27	12.22
F_2	6.99	100.00	8.35
F_3	12.10	88.18	16.93
S.E.(m)±	0.186	1.314	0.359
C.D. (at 5%)	0.557	3.940	1.076
Spacing levels			
S_1	9.02	93.52	12.34
S_2	7.44	94.00	11.14
S_3	10.38	92.93	14.02
S.E.(m)±	0.186	1.314	0.359
C.D. (at 5%)	0.557	3.940	1.076
Interaction (F x S)			
F_1S_1	7.83	93.07	12.36
F_1S_2	7.70	96.13	8.80
F_1S_3	7.70	87.60	15.51
F_2S_1	5.44	100.00	6.24

F_2S_2	5.27	100.00	10.20
F_2S_3	10.26	100.00	8.60
F_3S_1	13.80	87.48	17.95
F_3S_2	9.34	91.20	14.44
F_3S_3	13.17	85.87	18.42
S.E.(m)±	0.322	2.276	0.621
C.D. (at 5%)	0.966	NS	NS

The data pertaining to plant height, number of leaves per plant, number of suckers per plant, leaf area and petiole length at 120 days after planting showed significant differences among the treatments and the data is presented in Table 2.

The highest plant height (71.18 cm) was recorded in treatment F_2 [125% recommended dose of NPK (100:75:75 kg/ha)] which was notably higher than other treatments and statistically at par (69.63 cm) with F_1 [100% recommended dose of NPK (80:60:60 kg/ha)]. However, the lowest plant height (66.40 cm) was observed in F_3 [75% of recommended dose of NPK (60:45:45 kg/ha)]. The plant spacing of S_2 (60 cm x 60 cm) noted maximum plant height (71.18 cm) at 120 DAP which was statistically at par with S_1 (60 cm x 45 cm) with a height of (69.63 cm). The minimum plant height (66.40 cm) was obtained in S_3 (60 cm x 30 cm). Nitrogen promotes leaf and stem development, phosphorus supports root growth, and potassium aids in nutrient absorption and overall plant vigor. When these nutrients are adequately supplied, taro plants can grow taller. However, insufficient or excessive fertilizer can lead to stunted growth or nutrient imbalances affecting plant height. Therefore, optimum fertilizer application is a key to achieve optimal plant height in taro (Bhatt *et al.* 2019) [2]. Similarly, the optimal spacing ensures that taro plants have enough space to develop fully leading to increased height and overall better growth. The result observed here is in agreement with (Kumar *et al.* 2016) [5]. The interaction effect of different levels of fertilizer and plant spacing showed significant impact on plant height at 120 DAP. The highest plant height (86.70 cm) was recorded in the F_2S_2 combination which was significantly higher than the other treatments whereas, the lowest (55.87 cm) was recorded in the F_3S_3 combination.

The maximum number of leaves per plant (5.66) was observed in treatment F_2 [125% of recommended dose of NPK (100:75:75 kg/ha)] which was significantly higher than rest of all other treatments and it was statistically at par with F_1 [100% recommended dose of NPK (80:60:60 kg/ha)], (5.35) while minimum number of leaves per plant (4.80) was recorded in treatment F_3 [75% of recommended dose of NPK (60:45:45 kg/ha)]. Plant spacing of S_2 (60 cm x 60 cm) produced the maximum number of leaves per plant (5.39) which was closely followed by S_1 (60 cm x 45 cm) (5.24). The minimum number of leaves per plant (5.19) was observed in plant spacing S_3 (60 cm x 30 cm). The results in relation to number of leaves might be due to adequate fertilizer application provides essential nutrients like nitrogen, phosphorus, and potassium which are crucial for leaf development. Nitrogen particularly promotes leaf growth and enhances overall plant vigor, leading to a higher number of leaves (Das *et al.* 2018) [3]. Plant spacing significantly affects the number of leaves on taro plants. Wider spacing allows each plant more access to light, water and nutrients which can enhance leaf production and lead to a higher number of leaves. With ample space taro plants can grow more robustly and develop a full canopy (Kumar *et al.* 2016) [5]. The F_2S_2 combination produced highest number of leaves (6.30) which was significantly greater than other treatments and found to be statistically at par (5.70) with F_2S_1 whereas, treatment combination F_3S_2 recorded lowest number of leaves (4.71). The similar results are in accordance with the findings of Akther *et al.* (2016) [1] and Bhatt *et al.* (2019) [2].

The maximum number of suckers per plant (6.86) was obtained in treatment F_2 [125% of recommended dose of NPK (100:75:75 kg/ha)] which was followed by F_1 [100% recommended dose of NPK (80:60:60 kg/ha)]. However, the minimum number of suckers per plant (4.77) was observed in treatment F_3 [75% of recommended dose of NPK (60:45:45 kg/ha)]. The maximum number of suckers per plant (5.79) was recorded in S_2 (60 cm x 60 cm) plant spacing, which was statistically at par with S_1 (60 cm x 45 cm), (5.62). The minimum number of suckers per plant (5.55) was observed in plant spacing S_3 (60 cm x 30 cm). Fertilizer application significantly influences the number of suckers in taro plants. Adequate fertilization provides essential nutrients that support overall plant growth and vigor which can lead to increased sucker production. Specifically, balanced levels of nitrogen, phosphorus and potassium promote robust growth and help the plant to produce more suckers. Nitrogen is particularly important for vegetative growth and can enhance sucker development. Proper spacing ensures that each taro plant has enough room to grow and produces higher number of suckers. Therefore, optimizing plant spacing is essential for maximizing sucker production and overall plant growth in taro cultivation. Kumar *et al*. 2016 [5] and Das *et al*. 2018 [3] reported similar results in taro.

The maximum leaf area (524.66 cm^2) was recorded in treatment F_2 [125% of recommended dose of NPK (100:75:75 kg/ha)] which was statistically at par with F_1 [100% recommended dose of NPK (80:60:60 kg/ha)], (510.91 cm^2). However the lowest leaf area (406.79 cm2) was noticed in treatment F_3 [75% of recommended dose of NPK (60:45:45 kg/ha)]. The highest leaf area (525.11 cm^2) was obtained in S_2 (60 cm x 60 cm) which was significantly higher than rest of all other treatments and the lowest (453.10 cm^2) was noticed in S_3 (60 cm x 30 cm). Adequate fertilization provides essential nutrients particularly nitrogen, phosphorus and potassium which are crucial for leaf development and overall growth similarly, wider spacing reduces competition and allows each plant to access more light and nutrients, promoting more leaf expansion (Shellikeri *et al.* 2019) [9].

The interaction effect of different levels of fertilizer and plant spacing had significant effect on leaf area. The highest leaf area (673.33 cm^2) was recorded in the F_2S_2 combination which was statistically at par with F_1S_1 (563.47 cm^2). The lowest leaf area (349.52 cm^2) was recorded in the F_3S_3 combination. Similar findings are in agreement with Akther *et al.* (2016) [1] and Bhatt *et al.* (2019) [2].

The maximum petiole length (77.63 cm) was observed in treatment F_2 [125% of recommended dose of NPK (100:75:75 kg/ha)] whereas, minimum petiole length (54.64

cm) was observed in treatment F_3 [75% of recommended dose of NPK (60:45:45 kg/ha)]. Petiole length also showed significant differences at different plant spacing in this context the maximum petiole length (66.51cm) was recorded in S_2 (60 cm x 60 cm) while the minimum petiole length (59.11 cm) was measured in S_3 (60 cm x 30 cm). The increase in petiole length in this treatment might be due to the fact that use of adequate levels of NPK which promotes healthy development and lead to longer petioles as nitrogen stimulates vegetative growth including petiole elongation. Further, wider plant spacing avails better exposure to light and in turn more benefit of lights thus better petiole growth was observed. The observation here is in agreement with Verma *et al.* (2012) [10] and Ogbonna *et al.* (2015) [7].

The interaction effect of different levels of fertilizer and plant spacing had significant effect on petiole length (cm). The highest petiole length (79.90 cm) was recorded in F_2S_2 combination which was statistically at par with F_2S_3 combination (77.07 cm). The lowest petiole length (31.33 cm) was recorded in F_3S_3 combination. Akther *et al.* (2016) [1] and Bhatt *et al.* (2019) [2] reported similar results.

Table 2: Effect of fertilizer, plant spacing levels and their interaction on growth traits of taro

Treatments	Plant height (cm)	Number of leaves plant^{-1}	Number of suckers plant^{-1}	Leaf area(cm^2)	Petiole length (cm)
Fertilizer levels					
F_1	69.63	5.35	5.33	510.91	56.25
F_2	71.18	5.66	6.86	524.66	77.63
F_3	66.40	4.80	4.77	406.79	54.64
S.E.(m)±	1.060	0.105	0.138	17.817	0.548
C.D. (at 5%)	3.177	0.314	0.414	53.409	1.643
Spacing levels					
S_1	63.77	5.24	5.62	464.15	62.91
S_2	81.49	5.39	5.79	525.11	66.51
S_3	61.95	5.19	5.55	453.10	59.11
S.E.(m)±	1.060	0.105	0.138	17.817	0.548
C.D. (at 5%)	3.177	0.314	0.414	53.409	1.643
Interaction (F x S)					
F_1S_1	63.31	5.13	5.08	563.47	47.95
F_1S_2	61.57	5.35	6.02	491.27	51.88
F_1S_3	66.43	5.58	4.90	478.00	68.93
F_2S_1	80.87	5.70	6.48	479.47	75.93
F_2S_2	86.70	6.10	7.64	673.33	79.90
F_2S_3	76.90	5.18	6.47	461.17	77.07
F_3S_1	64.71	4.88	5.29	420.13	64.83
F_3S_2	65.28	4.82	5.28	450.73	67.77
F_3S_3	55.87	4.71	3.73	349.52	31.43
S.E.(m)±	1.83	0.181	0.239	30.860	0.949
C.D. (at 5%)	5.502	0.543	0.716	92.507	2.846

Conclusion

In view of the findings and results presented above, it may be concluded that the treatments F_2 [125% of recommended dose of NPK (100:75:75 kg/ha) and S_2 (60 cm x 60 cm)] found significantly superior over all other treatments which was found to be statistically at par with treatments F_1 [100% recommended dose of NPK (80:60:60 kg/ha) and S_1 (60 cm x 45 cm). In relation to the combined effect, treatment F_2S_2 found to be superior for all growth parameters under Marathwada conditions.

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