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Research article

Correlation and effects of pruning and plant spacing on flower, fruit and seed traits in jatropha

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Abstract

Importance of the work: Optimization of plant spacing and applying hard pruning in jatropha cultivation are promising ways to improve production.

Objectives: To examine the effects of pruning and planting spacing on jatropha traits: flower, fruit and seed characteristics.

Materials and Methods: A study was conducted on 14 jatropha varieties, evaluating them under narrow and standard spacing conditions for 2 yr. The plants were pruned after the initial year to stimulate new growth; data were collected on flower, fruit and seed characteristics.

Results: Notably, while plant spacing had a minimal impact on the studied jatropha traits, pruning significantly accelerated flowering and enhanced inflorescence number, seed size and weight, albeit reducing the number of seeds per fruit. In addition, there was a strong correlation between the inflorescence number in jatropha and the growth and yield traits, with Pearson's correlation coefficient values from 0.53 (significant at $p < 0.05$) up to 0.89 (significant at $p < 0.01$).

Main finding: Reducing plant spacing did not affect jatropha flowering, fruiting or seed setting; rather, pruning enhanced these traits and was correlated with a higher yield.

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Introduction

Jatropha (*Jatropha curcas* L.) is recognized for its versatility as a biofuel feedstock and diverse industrial and medicinal applications (Lama et al., 2018). While there is growing interest in the potential of jatropha production, the development of its full potential requires the implementation of enhanced cultivation practices and the development of high-yielding varieties of jatropha. Regrettably, the cultivation practices of jatropha remain inadequately established from various aspects, particularly plant spacing and pruning techniques, underscoring the urgency of this study. Furthermore, optimal plant spacing is vital in jatropha cultivation as it may directly influence yield efficiency and thus overall economic viability.

Jatropha is a perennial shrub known for its longevity spanning decades and expansive canopy that has been subjected to breeding efforts, resulting in new genotypes with reduced canopy sizes (Negussie et al., 2015). Notably, genotypes achieved through the interspecific hybridization of *J. curcas* with *J. integerrima* offer selectable options for cultivation; Tanya et al. (2011) were the first to report on the relationships among five jatropha species and one castor bean genus to identify species capable of successful interspecific crosses using inter simple sequence repeat markers. Muakrong et al. (2014a, b) crossed woody biomass and ornamental plants of *J. curcas* and *J. integerrima*. One et al. (2014a) demonstrated the inheritance of awareness and erect growth habits in *J. curcas* × *J. integerrima* progeny and found a gene controlling its trait in F_2 and BC_1F_1. Subsequently, One et al. (2014b) studied the phenotypic and genotypic variabilities of the F_2 population in *J. curcas* × *J. integerrima*. In addition, Arunyanark et al. (2022) studied the effects on biomass yield stability of carrying out 1 yr of pruning at 1 yr after planting in the field. Furthermore, Arunyanark et al. (2023a, b) found that not all jatropha genotypes had hard pruning and short pruning cycles, that were influenced by genetic and environmental factors. Reducing planting spacing can increase jatropha plant density and yield per area, considering that population density is crucial to avoid resource competition and the spread of pests and diseases and to increase seed yield (Negussie et al., 2015; Arunyanark et al., 2024).

As jatropha is a perennial plant, it can be harvested for multiple years. However, its continuous growth and large canopies can increase plant competition and introduce harvesting challenges. Thus, pruning jatropha branches is important for managing the plant size and making maintenance and harvesting easier (Santos et al., 2016). Pruning is the selective removal of plant growth from herbaceous or perennial plants and is a powerful tool for sustaining plant health and vitality. For example, pruning has several advantages including extended flowering time, generation of new shoots, and encouraging growth, while in addition to shaping and sizing, pruning can greatly influence the flowering and fruiting processes, providing an opportunity to enhance jatropha cultivation (Tosto et al., 2022).

There has been extensive research on the impact of different pruning levels and cycles on jatropha to identify the optimal pruning practices for cultivation (Santoso et al., 2016; Sumed et al., 2019). Subsequently, investigations into rejuvenating pruning for jatropha have emerged, involving the removal of old, overgrown branches to foster the growth of new, stronger branches through hard pruning (Grijalva-Contreras et al., 2020; Noda-Leyva et al., 2021).

Recent efforts have focused on developing new jatropha plants, especially interspecific ones, to boost yield potential (Bai et al., 2025). Furthermore, refining jatropha cultivation techniques has included a narrower planting spacing and the implementation of hard pruning with shorter cycles (Arunyanark et al., 2024). Despite these advancements, more research is needed regarding the impact of these updated cultivation practices on the flowering, fruiting and seed setting of jatropha. Therefore the current study aimed to investigate the effects of pruning and planting spacing on jatropha traits and to explore their correlations with flower, fruit and seed performance.

Materials and Methods

Experimental design and treatments

The research was carried out at the Department of Agronomy, Kamphaeng Saen Campus, Kasetsart University, Thailand, specifically in the jatropha research field, situated at 14° 01' 21.97" N; 99° 58' 42.04" E and an altitude of 7.25 m above sea level.

The experiment used a split-plot randomized complete block design with four replicates. The main plot consisted of two different plant spacing (PS) treatments: narrow spacing (1 m × 1.5 m = 6,666 plants/ha) and standard spacing (2 m × 1.5 m = 3,333 plants/ha). In total, 14 jatropha genotypes (G) were studied within the subplots, as described by Arunyanark et al. (2024).

Data collection

Data for jatropha plants were collected from each subplot on 11 and 7 plants with narrow and standard spacing, respectively.

The days of first flowering (DFF) of each plant was recorded and the average flowering time for each subplot was calculated. Monthly counts were carried out on newly emerged inflorescence of plants aged 1 yr to determine the number of inflorescences per plant (IPP), followed by recording the number of fruits per inflorescence (FPI) and the number of seeds per fruit (SPF). The annual yields from the first-year recording (plant crops) and after pruning (ratoon crops) were carefully and systematically measured in terms of the year (Y). Monthly collections of ripe fruits were diligently and consistently carried out from the plants in the middle row of each subplot. These measurements provided valuable insights into crop productivity and yield potential, contributing greatly to a comprehensive and enlightened understanding of plant performance. A sample of 30 undamaged fruits was randomly selected and the numbers of seeds per fruit were counted. The jatropha fruits were sun-dried for approximately 1 wk and then weighed to determine the average weight per plant. Seeds were carefully extracted and 20 healthy seeds were randomly selected from each subplot for seed length (SL), seed width (SW) and seed thickness (ST). Furthermore, 100 intact seeds from each subplot were weighed to calculate the 100-seed weight (100SW), ensuring a fair representation of the seed characteristics.

Statistical analysis

Over the experimental period of 2 yr, a split-plot randomized complete block design was used to examine the impact of pruning, plant spacing, and genotype on jatropha flowering, fruiting and seed set. Then, separate variance calculations were made for each plant spacing and for the plant and ratoon crops. Statistical means were compared using Duncan's new multiple range test and simple correlations were calculated between flower, fruit and seed traits using the R program (R Core Team, 2021). A p value of < 0.05 was considered significant, and p < 0.01 was considered highly significant.

Results and discussion

Effects of hard pruning and plant spacing

Based on the results in Table 1, there were notable distinctions between the plant and ratoon crops (Y) for all traits except SL, whereas 14 jatropha genotypes (G) were significantly different across all characteristics. There were no significant differences for plant spacing (PS) and the interaction between crop and plant spacing (Y × PS) for any traits. The interaction between crop and genotype (Y × G) had an impact on all traits, with the exception of the number of inflorescences per plant (IPP) and seed width (SW). There was a significant difference only in the IPP of the interaction between plant spacing and jatropha genotype (PS × G).

The ratoon crop commenced flowering earlier and had a higher IPP value than the plant crop. However, the plant crop produced more fruit per inflorescence than its ratoon counterpart. There were no significant differences for PS with all traits, except for IPP of standard spacing being 25.80 higher than for the narrow spacing (20.46), as shown in Table 2.

Advanced cultivation techniques, including pruning and optimizing plant spacing, have been applied to enhance jatropha yield. For example, research has demonstrated that pruning effectively promotes branching, growth, and flowering, leading to increased productivity (Huang et al., 2020). The results of the current research underscored the considerable effects of pruning on jatropha plants, including earlier flowering, as well as larger inflorescence and seed.

Table 1 Pooled analysis of variance during 2 yr in split-plot design for inflorescence, fruit and seed characteristics of jatropha

Source of variance	df	Mean square value							
		DFF	IPP	FPI	SPF	SL	SW	ST	100SW
Year (Y)	1	15,014 **	2,917 **	97.68 **	0.12 *	0.10	0.34 *	1.56 **	1,824 **
Reps. within year	6	203	360	7.87	0.02	0.55	0.03	0.04	84
Plant spacing (PS)	1	74	1,598 *	0.26	0.01	0.00	0.07	0.05	22
Y × PS	1	82	100	12.84	0.01	0.43	0.00	0.00	61
Error A	6	78	33	2.01	0.03	0.45	0.02	0.06	21
Genotype (G)	13	916 **	662 **	9.98 **	0.54 **	12.94 **	3.76 **	1.53 **	1,267 **
Y × G	13	759 **	65	2.64 **	0.04 *	0.31 *	0.09	0.07 **	60 **
PS × G	13	85	177 **	1.63	0.03	0.15	0.03	0.02	9
Y × PS × G	13	150	48	0.82	0.02	0.22	0.04	0.03	18
Error B	156	118	59	0.98	0.02	0.14	0.06	0.03	14

df = degrees of freedom; Y = first-year record (plant crops) and after pruning (ratoon crops); PS = narrow spacing and standard spacing; DFF = days to first flowering; IPP = number of inflorescences per plant; FPI = number of fruits per inflorescence; SPF = number of seeds per fruit; SL = seed length; SW = seed width; ST = seed thickness; 100SW = 100-seed weight.

* = significant (p < 0.05); ** = highly significant (p < 0.01).

Table 2 Comparisons of plant crop and ratoon crop under different plant spacing in inflorescence, fruit and seed characteristics of jatropha

Treatments	DFF (days)	IPP (inflorescences)	FPI (fruits)	SPF (seeds)
Year				
Plant crop	73.56 A	19.52 B	6.55 A	2.72 A
Ratoon crop	57.18 B	26.74 A	5.22 B	2.68 B
F test	**	**	**	*
Plant spacing				
Narrow spacing	64.80	20.46 b	5.85	2.71
Standard spacing	65.95	25.80 a	5.92	2.69
F test	ns	*	ns	ns
Least significant difference (p = 0.05)	2.68	4.57	0.75	0.04
	SL (mm)	SW (mm)	ST (mm)	100SW (g)
Year				
Plant crop	18.15	10.94 B	8.69 B	63.22 B
Ratoon crop	18.11	11.02 A	8.86 A	68.93 A
F test	ns	*	**	**
Plant spacing				
Narrow spacing	18.13	11.00	8.79	65.76
Standard spacing	18.13	10.96	8.76	66.39
F test	ns	ns	ns	ns
Least significant difference (p = 0.05)	0.21	0.07	0.06	2.27

DFF = days to first flowering; IPP = number of inflorescences per plant; FPI = number of fruits per inflorescence; SPF = number of seeds per fruit; SL = seed length; SW = seed width; ST = seed thickness; 100SW = 100-seed weight.

Mean values with different uppercase letters in same column denote significant differences between years; different lowercase letters in same column denote significant differences between plant spacing.

ns = non-significant ($p \geq 0.05$); * = significant ($p < 0.05$); ** = highly significant ($p < 0.01$).

Pruning stimulates dormant buds, leading to increased leaf area and faster dry matter accumulation (Huang et al., 2020), as well as directly promoting flower bud growth (Girault et al., 2010) and substantially increasing the yield of specific perennial plants when proper pruning techniques are used (Tosto et al., 2022). Based on these findings, pruning techniques could enhance plant growth and yield, leading to more efficient agricultural practices that are based on nutrient accumulation (Dambreville et al., 2015).

Pruning, a technique that reshapes the balance between vegetative and reproductive growth, accelerates flowering (Zhang et al., 2022). This mechanism not only boosts the effectiveness of photosynthesis and nutrient accumulation by promoting electron transfer during photosynthetic reactions but also substantially enhances canopy structure and air movement, thereby optimizing photosynthetic efficiency (Forrester et al., 2012). This increased photosynthetic capacity results in the rapid accumulation of essential nutrients that are vital for after pruning (Ghosh et al., 2011). In the context of cassava and cotton cultivation, pruning techniques and growth regulators have been extensively studied and have consistently been shown to enhance flowering, fruit set, and ultimately, yield (Nie et al., 2021; Rodrmguez et al., 2023; Hyde et al., 2024). Pruning enhances the yield by promoting the growth of branches and vegetative parts (Pineda et al., 2020).

Pruning substantially affects the number of inflorescences per plant in jatropha by stimulating branch growth (Arunyanark et al., 2022; 2023a, b), with such causes being attributed to various environmental factors (Hendry et al., 2021). Historically, increasing crop yield has involved boosting plant density and cultivating less competitive varieties (Tosto et al., 2022). In addition, pruning reduces interplant competition, making it valuable in tree systems (Lima et al., 2016). Denser planting may increase yield; however, this requires caution because of the potential competition from neighboring plants. Population density substantially affects the development of *J. curcas*, with broader spacing allowing for more vigorous growth, as well as increased branching and seed production (Silveira et al., 2019). Based on the results of the current experiments, wider spacing encouraged better growth and greater IPP values, although optimizing plant spacing might compensate for total yield. Adjusting plant spacing in jatropha offers a major opportunity to improve the yield per area.

Jatropha genotypes on flowering, fruiting, and seed setting

Table 3 shows there were significant differences in flower, fruit and seed performance among the 14 jatropha genotypes. The average DFF ranged from 53.46 d in KUJL112 (early flowering) up to 74.88 d in KUJL110 (late flowering). Based on the annual yields from the first-year records (plant crops) and after pruning (ratoon crops), KUJL112 and KUJL101 were the earliest of the flowering plants (51.25 d) and ratoons (52.26 d), respectively. The late flowering stages of the plant and ratoon crops were for KUJL110 (90.82 d) and KUJL64 (66.17 d), respectively (Fig. 1a).

Table 3 Mean flower, fruit and seed performance of 14 jatropha genotypes

Variety	DFF (days)	IPP (inflorescences)	FPI (fruits)	SPF (seeds)	SL (mm)	SW (mm)	ST (mm)	100SW (g)
KUJL23	55.43±2.27$^{f–h}$	30.61±7.13^{ab}	5.78±1.05$^{c–e}$	2.16±0.09^{f}	18.19±0.18^{e}	10.25±0.11^{g}	8.69±0.10^{fg}	58.26±1.13^{fg}
KUJL30	59.38±3.32$^{e–h}$	15.74±4.62^{ef}	5.88±0.36$^{c–e}$	2.63±0.15^{d}	19.33±0.25^{b}	11.74±0.09^{a}	8.96±0.08^{cd}	74.17±3.30^{bc}
KUJL64	73.49±9.64^{ab}	19.77±1.88$^{c–e}$	6.50±0.73$^{a–c}$	2.74±0.12^{bc}	17.49±0.20^{h}	10.48±0.05^{f}	8.40±0.04^{i}	56.13±0.48^{gh}
KUJL70	54.72±2.76^{gh}	21.40±7.02$^{c–e}$	6.93±0.85^{a}	2.76±0.09$^{a–c}$	19.00±0.17^{c}	11.23±0.04^{c}	9.02±0.05^{bc}	75.38±4.63^{b}
KUJL71	71.89±18.75$^{a–c}$	31.91±7.90^{a}	6.37±1.17$^{a–c}$	2.79±0.09$^{a–c}$	17.01±0.14^{i}	10.89±0.07^{e}	8.50±0.06^{hi}	60.15±3.81^{f}
KUJL101	62.49±12.76$^{d–g}$	23.33±7.36^{cd}	4.85±0.63^{fg}	2.84±0.05^{ab}	17.79±0.34^{fg}	11.18±0.14^{cd}	8.53±0.11^{h}	64.65±2.28^{e}
KUJL105	63.41±9.96$^{c–f}$	25.31±3.39^{bc}	6.90±2.12^{a}	2.87±0.06^{a}	17.54±0.14^{gh}	10.95±0.07^{e}	9.10±0.08^{b}	67.83±2.82^{d}
KUJL106	66.02±9.15$^{b–e}$	35.73±12.62^{a}	4.42±0.50^{g}	2.82±0.07$^{a–c}$	18.07±0.07^{e}	10.85±0.11^{e}	8.74±0.20^{ef}	68.81±3.84^{d}
KUJL109	71.84±18.68$^{a–c}$	17.77±6.99^{de}	5.53±1.11$^{d–f}$	2.76±0.03$^{a–c}$	16.98±0.12^{i}	10.05±0.26^{g}	8.26±0.16^{j}	54.00±2.45^{h}
KUJL110	74.88±20.25^{a}	24.22±4.63^{c}	6.03±0.98$^{b–e}$	2.71±0.12^{cd}	16.98±0.26^{i}	10.96±0.09^{de}	8.57±0.11^{gh}	59.23±4.10^{f}
KUJL112	53.46±2.62^{h}	20.22±9.50$^{c–e}$	6.17±0.37$^{a–d}$	2.47±0.10^{e}	19.65±0.15^{a}	11.01±0.09$^{c–e}$	9.27±0.07^{a}	78.96±4.56^{a}
Cn	74.44±13.57^{ab}	21.07±5.44$^{c–e}$	4.97±0.90^{fg}	2.71±0.08^{cd}	18.05±0.45^{ef}	11.49±0.17^{b}	8.75±0.32^{ef}	56.12±9.23^{gh}
M8	69.58±20.26$^{a–d}$	11.86±4.64^{f}	5.31±0.56^{ef}	2.76±0.04$^{a–c}$	18.62±0.20^{d}	11.04±0.10$^{c–e}$	8.85±0.20^{de}	71.93±3.10^{c}
M8Cn	64.19±13.23$^{c–e}$	24.93±8.26^{c}	6.77±1.53^{ab}	2.77±0.09$^{a–c}$	19.12±0.18^{bc}	11.64±0.11^{ab}	9.22±0.11^{a}	79.40±6.27^{a}
Mean±SD	65.37±7.57	23.13±6.43	5.89±0.79	2.70±0.18	18.13±0.90	10.98±0.48	8.78±0.31	66.07±8.90
CV (%)	16.63	33.34	16.80	5.31	2.08	2.25	1.86	5.60

DFF = days to first flowering; IPP = number of inflorescences per plant; FPI = number of fruits per inflorescence; SPF = number of seeds per fruit; SL = seed length; SW = seed width; ST = seed thickness; 100SW = 100-seed weight; CV = coefficient of variation.
Mean ± SD values in same column with different lowercase superscripts indicate significant differences ($p < 0.05$) among jatropha genotypes.

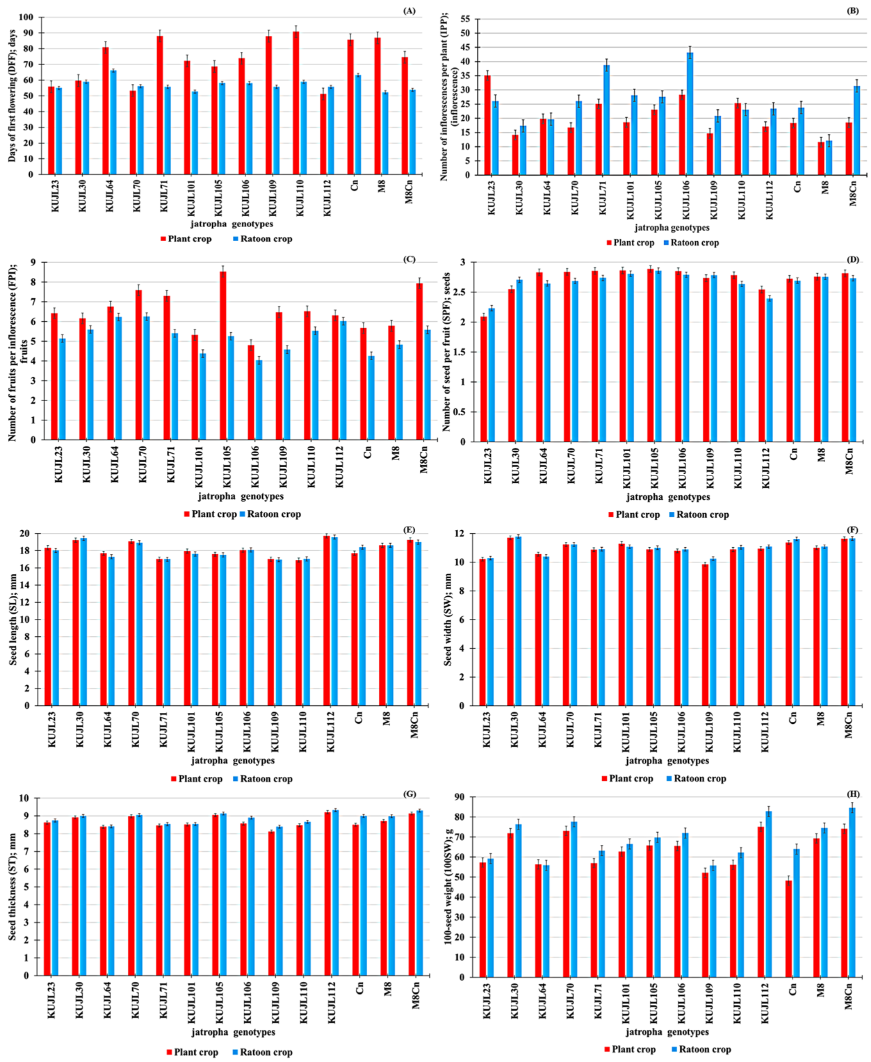

Fig. 1 Comparisons of genotypes combined over two plant spacing for days of first flowering; DFF (A), number of inflorescences per plant; IPP (B), number of fruits per inflorescence; FPI (C), number of seeds per fruit; SPF, (D) Seed length; SL (E), Seed width; SW (F), Seed thickness; ST (G), and 100-seed weight; 100SW (H) of jatropha in plant crop and ratoon crop. Error bars represent ± SE.

There were higher-than-expected IPP values of over 30 inflorescences in KUJL30 (30.60) and KUJL106 (35.73), while the lowest value was for M8 (11.86). The IPP values for the plant crops were in the range 8.07–32.29, while in the ratoon crops, the range was 15.65–43.14 inflorescences per plant. IPP values exceeded 30 in the plant crop KUJL71 (32.29), while in the ratoon crops, this value was exceeded by KUJL106 (43.15), KUJL23 (34.46), and KUJL71(31.53), as shown in Fig. 1B.

The number of fruits per inflorescence (FPI) was in the range 4.42–6.90 fruits. Among the varieties, KUJL105 had the highest FPI, whereas KUJL106 had the lowest, in contrast to its IPP performance. The FPI in the plant crop was higher than in the ratoon crop, especially for KUJL106 that had the lowest FPI values in both the plant and ratoon crops (4.80 and 4.04, respectively), while KUJL105 had the highest FPI value in the plant crop (8.54) in contrast to its ratoon crop (8.29), as shown in Fig. 1C. The number of seeds per fruit (SPF) observed in the 14 Jatropha genotypes did not exceed three seeds, for either the plant or ratoon crops, as illustrated in Fig. 1D. Measurements of the seed dimensions revealed that ranges in SL, SW and ST were 16.98–19.65 mm, 10.05–11.74 mm and 8.26–9.27 mm, respectively. Figs. 1E–1G illustrate the SL, SW and ST values for both the plant and ratoon crops. M8CN had the highest average 100SW (79.40 g), with 74.14 g for its plant crop and 84.67 g for its ratoon crop, followed by KUJL112 (average of 78.96 g), with 75.08 g for its plant crop and 82.84 g for its ratoon crop (Fig. 1H).

Jatropha improvement has been reported based on reducing suitability and narrowing the plant spacing (Lima et al., 2016; Santos et al., 2016). Crossbreeding *J. curcas* with smaller-canopied *J. integerrima* has yielded interspecific hybrids with more compact biomass growth (Arunyanark et al., 2022).

There are various pruning techniques, including hard pruning, cutting shrubs back to 15–30 cm above the ground to stimulate regrowth, rejuvenating pruning and removing old limbs to prompt vigorous new growth (Grijalva-Contreras et al., 2020). These strategies can greatly affect the plant growth and yield (Sumed et al., 2019). While some jatropha genotypes are not conducive to pruning (Santoso et al., 2016), others cannot endure hard pruning (Noda-Leyva et al., 2021; Arunyanark et al., 2023a).

There were several important findings from the current study. Frequently, pruning during the initial year resulted in accelerated flowering, increased inflorescences per plant and higher seed weights in most of the jatropha species studied.

In addition, there were significant variations in flowering, fruiting and seed-setting traits among these jatropha genotypes. For example, the improved jatropha KUJL23 had notble traits, being known for its early flowering, abundant inflorescence and high seed weight, is noteworthy for its traits. KUJL112 plants displayed early flowering and had substantial seed weights. In addition, improved jatropha types, such as KUJL23, KUJL71 and KUJL106, outperformed the original jatropha genotypes Cn, M8, and M8Cn in inflorescence production, underscoring the potential of inter-specific hybridization to enhance desired traits. This notable development has led to an increased preference for interspecific hybrids with superior yields over their progenitors.

Relationships between flowering, seed setting and growth traits

Based on the current results, there was a critical link between the seed size and 100-seed weight of jatropha in both plant and ratoon crops. The results revealed highly significant positive associations between seed dimensions and seed weight, with correlation coefficients of 0.77, 0.59 and 0.85, respectively, for different measurements (Figs. 2A–2C).

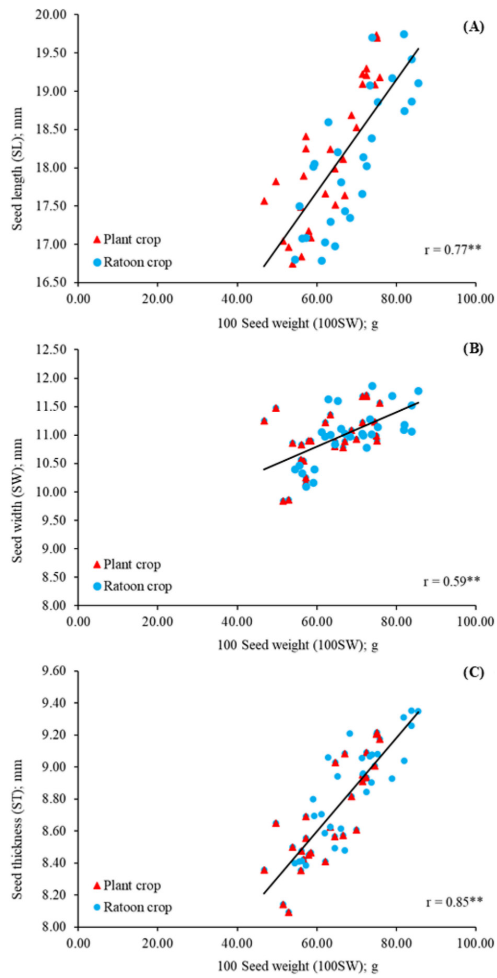

Fig. 2 Correlation between seed traits across plant crop and ratoon crop ($n = 56$) of jatropha: (A) 100-seed weight (100SW) and seed length (SL); (B) 100SW and seed width (SW); and (C) 100SW and seed thickness (ST). r = correlation coefficient; ** = highly significant ($p < 0.01$).

Thus, jatropha with larger seeds tended to be heavier, which is important for understanding seed development and crop yield. Examining plant spacing in both the plant and ratoon crops yielded interesting results. For example, there were positive associations between the number of inflorescences per plant and various growth characteristics (Table 4). These traits included plant height (r = 0.29–0.81**), canopy width (r = 0.51–0.85**), number of primary branches (r = 0.11–0.72**) and number of secondary branches (r = 0.62*–0.87**). These strong connections between inflorescence numbers and these growth parameters suggested that a higher abundance of inflorescence could make a major contribution to jatropha yield—a practical implication worth considering.

The correlation coefficients between days of first flowering (DFF) and SL, SW and ST were -0.73, -0.67, and -0.61 (data not shown). However, specific data that supported this observation are available. This suggested that a delay in flowering may lead to the production of smaller seeds. Notably, this correlation was not observed in the ratoon crops, suggesting a potential difference in the relationship between flowering time and seed size in different crop types—a topic that warrants further investigation.

Seed size was closely related to seed weight, which is a critical factor for production quality. Larger seeds are known to yield higher oil content, increase productivity, improve germination rates and enhance seedling vigor, factors that collectively contribute to the overall productivity (Lama et al., 2018). The importance of seed size extends beyond economic returns and processing efficiency as it also affects oil quality, plant health and environmental adaptability (Makinde et al., 2020). The results of the current research have underscored the strong correlation between inflorescence number in jatropha and key growth and yield traits. The abundant growth of jatropha, characterized by its numerous branches, significantly affected inflorescence production. As noted in other studies, pruning can positively influence jatropha growth and branch proliferation (Arunyanark et al., 2022; 2023a, b). Furthermore, the current findings have established a direct link between branch number and inflorescence count, suggesting that pruning interventions could enhance inflorescence formation in jatropha, thereby increasing yield potential. In conclusion, reducing plant spacing did not affect jatropha flowering, fruit development or seed set. Pruning significantly affected jatropha flowering, fruiting and seed setting. Variations in flowering, fruiting and seed-setting traits among genotypes underscored the importance of tailored cultivation approaches. Pruning enhanced these traits in most of the studied jatropha genotypes. Additionally, seed size was strongly correlated with seed weight in the studied jatropha, while inflorescence abundance was related closely to growth traits and yields.

Conflict of Interest

The authors declare that there are no conflicts of interest.

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Table 4 Correlation coefficients (*r*) between inflorescences per plant with growth and yield traits of jatropha in plant crop and ratoon crop under different plant spacing (n=14)

Inflorescences per plant (IPP)	Plant height	Canopy width	Number of primary branches	Number of secondary branches	Total fruit weight	Total seed weight
Plant crop						
Narrow spacing	0.45	0.61 *	0.11	0.73 **	0.52	0.46
Standard spacing	0.67 **	0.85 **	0.21	0.87 **	0.89 **	0.85 **
Pooled (n = 28)	0.59 **	0.79 **	0.16	0.80 **	0.78 **	0.72 **
Ratoon crop						
Narrow spacing	0.29	0.51	0.72 **	0.77 **	0.56 *	0.53 *
Standard spacing	0.81 **	0.83 **	0.36	0.62 *	0.77 **	0.74 **
Pooled (n = 28)	0.65 **	0.75 **	0.56 **	0.73 **	0.74**	0.71 **

* = significant ($p < 0.05$); ** = highly significant ($p < 0.01$).

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