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Pruning, cropping pattern and spacing regulation to enhance growth, production and seed quality of Jackbean (*Canavalia ensiformis* L)

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Abstract

The research was aimed to enhance growth, production, and seed quality of Jack Bean through pruning, cropping pattern and spacing regulation. The research was carried out from Mei to October 2016 at Puwasari Village, Dramaga, Bogor - Indonesia and be countinued by seed testing (December 2016) at Seed Testing Laboratoty, Bogor Agricultural University. The research was arranged in a Completely Randomyzed Block Design (CRBD) with 6 treatments, consisted of: Without pruning treatment using square spacing pattern and spacing 100cm x 100cm, Without pruning treatment using square spacing pattern and spacing 70cm x 70cm, Without pruning treatment using double row pattern and spacing 50cm x 50cm x 100cm, Pruning treatment using square spacing pattern and spacing 50cm x 50cm, Pruning treatment using square spacing pattern and spacing 70cm x 70cm, Pruning treatment using double row pattern and spacing 50cm x 50cm x 100cm. The experiment was replicated by three replications. The result research showed spacing regulation and pruning has significantly effect to some variables observed. The wider spacing showed the better growth. The treatment of without pruning treatment using square spacing pattern and spacing 70cm x 70cm (P2) resulted better growth, while the treatment of pruning treatment using square spacing and spacing 70cm x 70cm (P5) resulted better seed quality, however the highest production was reached by pruning treatment using double row pattern and spacing 50cm x 50cm x 100cm (P6).

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Introduction

Jack bean is a leguminose species that has high nutrition compositions and can be used as subsitutuion of soybean in necessity of food industry. The Jack bean contains 23,8-27,6g protein, 45,2-56,9g carbohydrate/100g material (Eke *et al.*, 2007). The antioxidant contained by Soybean i.e 3.442g/ grain, and the antioxidant contain of Jackbean i.e. 2.581g/100 gram seed, and this antioxidant can prevent free radical (Istianti, 2010). The Jack bean production about 3,9-4,6ton/ha (Usman *et al.*, 2013) and more high than soybean production about 0,6-2,0 ton/ha (Istiqomah and Krismawati, 2015).

The problem faced in Jack bean cultivation is high loss flowers and pod that direclty will cause the low production. Egli (2015) stated that flower, young pods, and growing pods on soybean would use the simultaneously as similate, where growing pods will use more assimilate than flower, and this conditions cause loss flower occured. According to Nazir (2016), number of pod loss/plant on Jack bean was affected by stem and branch pruning that relate with fotosintate insufficiency for embryo development. The high flower and pod loss directly will affect the production quantity and possibly also affect the quality of seed produced. Oskovie and Divsalar (2011) stated that physiology quality (seed viability and vigour) can be affected by plant growth, where the growing plant in suitable environmental will be produced the high quality of seed.

Forming and development of reproductive phase relates with grain filling process and food reserves accumulation during seed development and maturity. The high flower and pod loss of Jack bean related with unbalancing of sinc and source, as well as the completion of among plant or parts of the plant to utilize the nutrition, water, light, and growth space.

In order to overcome the problems faced, then pruning, cropping pattern, and spacing regulation were expected to be solution for reducing of flower fall and pod loss. Pruning, cropping pattern and spacing regulation were expected will increase the efficiency of light use by plant in photosyntesis process, more photosintate product that allocated to generative organ development. Pruning will render more space; offer the opportunity to the flower and pod development, and insect that support the pollination process. More and more light come in to plant, can augment the photosintate product and utilized by plant to metabolism and growth (Zuchri, 2007).

Generally, this research aims to get the proper cropping pattern and spacing to enhance the growth, production, and seed quality of Jack bean, and the study of pruning to optimally the growth and production of Jack bean.

Materials and methods

Time, Place and Experiment Design

The research was carried out from May to October 2016 in Purwasari Village, Dramaga, Bogor–Indonesia, and to be continued by seed quality testing on December 2016 at Seed Testing Laboratory, Bogor Agricultural University. The research was arranged in Completely Randomized Block Design (RCBD) with 6 treatments and three replications, so obtained 18 experiment units. The treatment applied consists of,

P1= without pruning, using square spacing pattern, spacing 100cm x 100cm, two seed/hole (18 planting holes)

P2= without pruning, using square spacing pattern, spacing 70cm x 70cm, one seed/hole (40 planting holes)

P3= without pruning, using double row pattern, spacing 50cm x 50cm x 100cm, one seed/hole (56 planting holes)

P4= pruning, using square spacing pattern, spacing 50cm x 50cm, one seed/hole (84 planting holes)

P5= pruning, using square spacing pattern, spacing 70cm x 70cm, one seed/hole (40 planting holes)

P6= pruning, using double row pattern, spacing 50cm x 50cm x 100cm, one seed/hole (56 planting holes)

Seed production

The experiment plot size was 6,0m x 3,5m, and with the various population according to cropping pattern and spacing. The population of planting hole for each treatment respectively, 18 for P2, 40 for P1 and P5, 84

for P4, and 56 for P3 and P6. Organic fertilizer was given at early planting, i.e 250g/ planting hole, and the seed collected from Bogor Agricultural University were planted at two weeks after organic fertilizer application. Fertilization was done once on two weeks after planting (WAP), i.e. 50kg Urea ha^{-1}, 100kg SP36 ha^{-1} and 112,5kg KCl ha^{-1}. Pruning was applied on the plant which has more 11 stem segments and 6 branch segment by cutting knife.

The observation covered, generative growth (time to flowering, time to first harvest, and harvest period), yield components (number of inflorescence/plant, number of pithy pod/inflorescence, number of pithy pod/plant, number of loss and empty pod, number of total pod/plant, number of seed/pod, production/ plant, and production/plot).

Testing of seed quality

The seed that were harvested then were tested in the Seed Testing Laboratory, Bogor Agricultural University. The testing of seed quality was consisted of physic and physiology quality. The testing of physic quality conducted was 1000 seed weight, and the testing of physiology quality i.e. Maximum growth potential (MGP), Germination percentage (GP), Germination speed (GP), Germination uniformity (GU) and Vigour index (VI).

Physic quality test

1000 seed weight was determined based on the International Seed Testing Association (ISTA) 2015, i.e. eight (8) pure seed replicates of 100 seeds were drawn randomly from the submitted sample. Each replicate weight is recorded in grams to three desimal place and the mean weight determined from these replicates. The mean weight of 100 is the used to calculate the 1000 seed weight.

Physiology quality test

Physiology quality test was conducted by germination test. 25 seeds were germinated in sand medium for each replicate, with planting depth about ± 1cm. The observation of paramaters was conducted based on ISTA (2015). Maximum growth potential (MGP) was observed on seventh day, germination percentage on fifth day and seventh day, germination uniformity on sixth day and vigour index on fifth day. Germination speed was observed daily from early germinating to final day. The normal seedling criteria used were seedling height about ± 10cm and the leaves opened perfectly.

Data Analysis

The data collected were analyzed by Fisher test (α, 0.05) using Statistical Tools Agricultural Research (STAR), and If showed significant effect will be continued to Duncan's Multiple Range Test (DMRT).

Results and discussion

Plant Growth

The observation of vegetative growth wasn't done caused by the treatment applied was pruning treatment. The observation of generative growth was done to time to flowering (DAP), time to first harvest (WAP), and harvest period. The statistical analys result of generative growth variables were presented on Table 1.

Table 1. Time to flowering, time to first harvest, and harvest period of Jack bean.

Treatment	Time to flowering (DAP)	Time to first harvets (WAP)	Harvest period (Day)
P1	55 [b]	19	28 [a]
P2	53 [a]	19	30 [a]
P3	55 [b]	19	28 [a]
P4	58 [c]	20	25 [b]
P5	55 [b]	19	27 [ab]
P6	55 [b]	19	28 [a]

The numbers followed by the same letters in the same column showed no significant different.

The result was presented on Table 1 showed the treatment applied has significantly effect to time to flowering and harvest period, however hasn't significantly effect to time to first harvest. The treatment on plant wasn't pruned, spacing 70cm x 70cm (P2) has faster time to flowering and the longer harvest periode; while the treatment on plant wasn't pruned and spacing 50cm x 50cm has slower time to flowering and shorter harvest period. The average time to flowering in plant wasn't pruned (P1, P2, P3) are 54,3 DAP and plant pruned (P4, P5, P6) are 56 DAP. The average time to first harvest in plant wasn't pruned were 19 WAP and 19,3 WAP for plant pruned, while the harvest period of plant wasn't pruned were

28,7 WAP and 26,7 WAP for plant pruned. Cropping pattern by square spacing pattern and spacing 50cm x 50cm (P4) resulted the slower time to flowering (50 DAP) and time to first harvest (20 WAP), and shorter harvest periode (25 day) than other treatments.

Other than genetic factor, environmental factor very important in growth of Jack bean. One of the most important environmental factors is climate factors (temperature, rainfall, and Relative Humidity (RH)). According to The Indonesian Agency for Agricultural Research and Development (2016) Jack bean plant grows optimum in the air temperature range, 20-32^{o}C at the trophic area. Asandhi (2008) stated that generally planting of Jack bean in Indonesia more suitable in the areas that has air temperature between 25^{o}C to 30^{o}C, the average of RH about 65%, light period about 12 hour/day or 10 hour/day minimally, and the optimum rainfall between 100 to 200mm/month. In this research, the temperature range was optimum conditions about 26,0-27,1^{o}C, rainfall and RH classified very high respectively 293-439mm/month and 82-86%/month. The high rainfall and RH at the research was held that was alleged as trigger the occurrence of disease attacks (*Sclerotium* sp fungus) in root, stem, and pod.

The domination of plant genetic characters was reflected by observation of time to first harvest. Pruning and/or spacing hasn't significantly effect to harvest time. Pruning and wider spacing will give more space to the incoming light, nevertheless not better than without pruning or closer spacing. This research result more showed that the plant wasn't pruned (P1, P2, and P3) tend to give the better yield, and the closer spacing (50cm x 50cm) tend to give the worse yield.

Yields Component

The observation of yield components covered, number of inflorescence/plant, number of pithy pod/inflorescence, number of pithy pod/plant, number of loss and empty pod, number of total pod/plant, number of seed/pod, production/plant, production/plot, and production/hectare were presented on Table 2 and Table 3.

Without pruning treatment using square spacing pattern on spacing 70cm x 70cm (P2) resulted the highest number of inflorescence, number of pithy pod/inflorescence and number of pithy pod/plant, while the pruning treatment using square spacing pattern on spacing 50cm x 50cm (P4) resulted the lowest number of inflorescence, number of pithy pod/inflorescence, number of pithy pod and number of total pod/plant (Table 2).

Table 2 also showed that the highest loss and empty pod occurred in pruning treatment using square spacing pattern on spacing 50cm x 50cm (P4) and the lowest loss and empty pod in without pruning treatment using square spacing on spacing 100cm x 100cm (P1), while the highest number of total pod/plant was resulted by without pruning treatment using square spacing and spacing 100cm x 100cm (P1).

Table 2. Number of inflorescence/plant (NIP), number of pithy pod/inflorescence (PPI), number of pithy pod/plant (PPP), number of loss and empty pod (LEP), and number of total pod/plant (TPP).

Treatment	NIP (*Inflorescence*)	PPI (Pod)	PPP (Pod)	LEP (Pod)	TPP (Pod)
P1	44,4 ^{b}	0,1 a	5,7 ^{ab}	11,2 ^{b}	26,2
P2	49,4 ^{a}	0,2 ^{a}	8,8 a	14,3 ^{a}	23,7
P3	43,3 ^{b}	0,2 ^{a}	7,3 ^{ab}	14,2 ^{a}	23,3
P4	37,8 ^{c}	0,0 ^{b}	1,6 ^{c}	15,8 ^{a}	21,0
P5	42,3 ^{b}	0,1 ^{a}	4,9 ^{b}	14,2 ^{a}	23,7
P6	43,0 ^{b}	0,2 ^{a}	7,0 ^{ab}	12,1 ^{b}	22,3

The numbers followed by the same letters in the same column showed no significant different.

The average of inflorescence number/plant (NIP=44,73 vs 41,03), number of pithy pod/*inflorescense* (PPI=0,17 vs 0,10), pithy pod/plant (PPP=4,93 vs 4,50), and total pod/plant (TPP=24,40 vs 22,33) were higher on plant wasn't pruned than plant pruned, except in number of loss and empty pod (LEP=13,23 vs 14,03). Based on planting pattern treatment, square spacing pattern on spacing 50cm x 50cm resulted the lowest number of

inflorescence/plant, pithy pod/inflorescence and plant, and total pod/plant, however the highest loss and empty pod. Planting by double row pattern and spacing 50cm x 50cm x 100cm (P3 and P6) tend to show the stable yield for five variables observed, although wasn't the best treatment (Table 2). Without pruning treatment using square spacing on spacing 100cm x 100cm (P1) resulted the highest total pod/plant, number of harvest pod/plant and seed/pod, nevertheless the lowest production/plot (Table 2 and 3).

Table 3 also showed that without pruning treatment using square spacing pattern and spacing 100cm x 100cm (P1) resulted the highest harvest pod/plant and number of seed/pod, nevertheless the lowest production/plot, while the highest production/sample plants was resulted by without pruning treatment using double row pattern and spacing 50cm x 50cm x 100cm (P3), and the highest production/plot was resulted by pruning treatment using double row pattern and spacing 50cm x 50cm x 100cm (P6). The low production/plot on without pruning treatment and spacing 100cm x 100cm was caused by fewer plant population (planting holes) i.e. 18 planting holes, or 36 plants. Square spacing pattern and spacing 50cm x 50cm is treatment that has the largest population, but its production is still relatively low. This is indicated by low number of inflorescence, number of pithy pod/inflorescence, number of pithy pod/plant, and production/sample plants, and high loss and empty pod.

Table 3. Harvest pod/plant (HPP), seed/pod (SP), production/sample plants (PPS), production/plot (PP) and production/hectare (PH).

Treatment	HPP (Pod)	SP (Seed)	Production		
			PPS (g)	PP (g)	PH (ton)
P1	16,0 [a]	10,6	70,7 [a]	3501,1 [d]	1,7
P2	9,4 [b]	10,3	67,8 [a]	4908,3 [c]	2,3
P3	9,1 [b]	10,2	93,9 [a]	6700,1 [b]	3,2
P4	5,2 [b]	9,6	27,7 [b]	5368,6 [c]	2,6
P5	8,2 [b]	9,7	74,8 [a]	4107,8 [d]	2,0
P6	10,2 [b]	10,1	72,5 [a]	7452,5 [a]	3,5

The numbers followed by the same letters in the same column showed no significant different.

Climate conditions (rainfall and Relative Humidity) at the research was held that are considered less suitable, so the growth and production resulted hasn't optimal. According to Asandhi (2008) the optimum growth of Jack Bean required monthly rainfall about 100-200mm and Relative Humidity about 65%, and in this research, the monthly rainfall about 293-439mm and Relative Humidity about 82-86%. This rainfall and Relative Humidity are classified high, and suspected to be causing many losses and rotting pods, so it directly reduces production dan quality of seed. In the pods, was also found the seed that has germinated, so cann't be used as the seeds.

Not all of numbers of inflorescence would resulted the flower and forming pod, that was shown by the least total pod/plant than number of inflorescence, where the inflorescence resulted many flowers that will develop to pod and seed. Generally, each inflorecence sequence has 8-16 interest, but the generated pod about 0-4 pods. The high loss and empty pod of the number of total pod produced also decreased the number of harvested pod and production, directly.

Planting regulation by square spacing pattern and spacing 50cm x 50cm (P4) resulted the more plant population, nevertheless evidently low growth and production. It was caused by plant competition to nutrition and water uptake, light, and growth space. The vegetative growth of Jack bean keep growing, although has towards to generative phase, and that cause the dense canopy, moreover the branch part of plant develop to other plant that there was side (the track among plants was covered).

The research result of Erawati and Awaludin (2016) reported that closer spacing of *Zea mays* was resulted the higher plants, the shorter cob, and the lower 100 seed weight and dry seed yield.

The research result of Hidayat (2008) also showed that peanuts planted in closer spacing resulted the decreasing of number of pod/plant, while the soybean

planted by closely spacing resulted the lower pod/plant, pithy pod/plant, and weight of seed/plant than wider spacing (Marliah *et al*., 2012).

Physic and physiology quality of seed harvested

The observation of physic and physiology quality covered 1000 seed weight, germination percentage, maximum growth potential, germination speed, uniformity of germination, and vigour index of seed. The observation result showed the treatment hasn't significantly effect to 1000 seed weight (TSW) and maximum growth potential (MGP), and has significantly effect to germination percentage (GP), germination speed (GS), germination uniformity (GU), and vigour index (VI) of seed harvested (Table 4).

Physic quality was shown by seed weight. The seed weight show seed contents that relates to food reserve accumulated, where the optimum food reserve would resulted the high viability and vigor of seed. Pruning and planting pattern regulation hasn't significantly effect to 1000 seed weight, however based on Table 4 showed planting by more closely spacing tend resulted the higher weight of 1000 seed. Pruning treatment showed the average of 1000 seed weight for the plant wasn't pruned (P1,P2, P3) resulted the higher 1000 seed weight (1285,7g) than plant pruned (1279,5g). The lower 1000 seed weight on plant pruned is caused by food reserves allocation at grain filling was directed for pruning injury recovery and new shoots establishment.

Table 4. 1000 seed weight (TSW), maximum growth potential (MGP), germination percentage (GP), germination speed (GS), germination uniformity (GU), and vigour index (VI) of Jack bean seed.

Treatment	TSW (g)	MGP (%)	GP (%)	GS (%/etmal)	GU (%)	VI (%)
P1	1293,1	84,0	69,3 ^{bc}	12,5 ^{cde}	32,0 ^{c}	21,3 ^{b}
P2	1276,0	89,3	76,0 ^{ab}	12,7 ^{bcd}	46,7 ^{ab}	28,0 ^{a}
P3	1288,0	88,0	74,7 ^{ab}	13,7 ^{abc}	36,0 ^{bc}	24,0 ^{b}
P4	1270,3	84,0	65,3 ^{c}	9,6 ^{e}	41,3 ^{abc}	17,3 ^{c}
P5	1284,4	92,0	84,0 ^{a}	16,7 ^{a}	48,0 ^{a}	24,0 ^{b}
P6	1283,8	85,3	70,7 ^{bc}	10,0 ^{de}	41,3 ^{abc}	29,3 ^{a}

The numbers followed by the same letters in the same coloumn showed no significant different.

According to Crop Plant Directorate (2011), 1000 seed weight of Jack bean was classified into three size groups, i.e. small size (<1000 g/1000 seed), medium (1000-1300g/1000 seed), and big size (>1300g/1000 seed). Based on the research result, the seed size mostly medium size.

Physiology quality of seed can be known by some indicators, i.e. maximum growth potential (MGP), germination percentage (GP), germination speed and uniformitas, and vigour index of seed. The higher weight of seed (P1) didn't ensure the better physiology quality. That were presented on Table 4, the pruning treatment using square spacing pattern, and spacing 70cm x 70cm (P5) resulted the better physiology quality. Quality of seed is affected by seed condition at the mother plant, besides is affected by internal and external factor.

The good quality of seed will be resulted by the good growth and healthy plant, and was harvested at physiology maturity. According to Suharsi *et al.* (2013), seed viability and vigour was affected by plant conditions in field. The plant development and grain filling process aren't optimal, will cause the low viability of seed harvested. The high rainfall at since planting and increased toward harvest and at harvest (September-October) is allegedly affected to quality of seed harvested.

Conclusion

The plant wasn't pruned tend to has the better growth, and the closer spacing showed the worse growth. The highest production was resulted by pruning treatment using double row, and spacing 50cm x 50cm x 100cm, which is 3,5 ton/ha.

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