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Research Article
Increasing Yield of *Vigna radiata* (L.) cv. Chai Nat 72 with Suitable Sowing Spacing

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Abstract

Background and Objective: *Vigna radiata* is the main source of protein for human consumption, characterized by the richness in minerals and vitamins. The increased competition caused in the denser populations has a direct effect on the yield capacity of the plants. This experiment compared the effect of three sowing spacing between plant space and row space (30×30, 25×50 and 50×50 cm) on the growth and yield components of *V. radiata* cv. Chai Nat 72. **Materials and Methods:** The seeds were drilled in a subplot size of 25 m^2 at the early and end of rainy seasons. Thinning to two plants per hole was carried out by hand at 14 days after planting. The study was laid out in a Randomized Complete Block Design (RCBD) with four replications of across sites, using Statistics software, version 8.0. **Results:** The results showed that the highest plant height was observed in 50 and 30 cm row spacing respectively where plants were spaced 25 and 30 cm within rows respectively. A maximum number of seeds per pod, biological yield per plant, 100 seed weight biological yield and grain yield were recorded for row spacing of 30 cm where plants were spaced 30 cm within rows at the early of the rainy season. **Conclusion:** This experiment showed that higher plant density may affect individual plants' access to light. However, light duration and light intensity are important factors at the flowering stage to decrease inflorescence number, fertility, pod numbers and grain yield.

Key words: Density, economic yield, growth, mungbean, optimum, season, spacing

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Mungbean (*Vigna radiata* (L.) Wilczek) is an important grain legume. It is currently cultivated on about six million hectares worldwide, most of which are located in South Asia[1]. Mungbean provides an important source of dietary protein for millions of people living in South and South East Asia[2]. The growing awareness of nutritional benefits has contributed to increasing demand for this crop in recent years. Most of the production was used for consumption and 90% were used in the industrial production of beansprouts, noodles and vermicelli[3]. In addition, mungbean production has also encountered significant problems, such as insect pests, disease outbreaks, low yield per area unit caused by using improper sowing spacing. *V. radiata* cv. Chai Nat 72 was bred with gamma irradiation, selected in both with and without the use of chemicals to prevent and eliminate worms flies penetrate the stems and yield evaluate in the experiment station and farmer's field[4]. The characteristics of *V. radiata* cv. Chai Nat 72, with an average plant height of 66 cm, the number of pods per plant 15 pods, 100 seeds weight 6.6 g, contains 45% of flour and 21.6% of protein. Grow well in all seasons and areas of Thailand. The average yield of 1,325 kg ha^{-1}, in the dry season, early rainy season and the end of the rainy season gives 1,387.50, 1,500 and 1,168.75 kg ha^{-1}, respectively[4].

Optimum row spacing plays an important role in contributing to the high yield because a thick plant population will not get proper light for photosynthesis and can easily be attacked by diseases. The maximum potential can be achieved by adopting the correct row spacing for each cultivar[5]. The sowing density of mung beans may ensure the optimal plant population as well as increase grain yield[6]. Several authors claim that the number of pods per plant is the yield component most affected by increasing plant density[7-9]. Probably, the reductions in species development can be explained by the fact that the higher population density, the lower light interception caused by plant overlap, where decreases in photosynthetic potential cause a reduction in carbon assimilation, reflecting directly on lower plant development and yield[9]. Increases in the spatial arrangement of plants promote a considerable reduction in the number of pods per plant, since they cause greater intraspecific competition in denser populations and thus interfere in plant production capacity[10]. Growing *V. radiata* cv. Chai Nat 72 in the north east Thailand need to investigate the best sowing spacing on growth and yield under rain conditions. This study was therefore aimed at assessing the effects of various sowing spacing on growth and grain yield of mungbean cv. Chai Nat 72.

MATERIALS AND METHODS

Planting preparation: The experiment was conducted at the experimental farm at the Faculty of Agriculture, Khon Kaen University, Khon Kaen Province, Thailand from July 2018-March 2020. The soil type is sandy loam (Yasothon soil series). Total rainfall was 788.66-859.83 mm at the early of rainy season and 596-747.83 mm at the end of rainy season during crop growth. The average maximum and minimum temperatures were recorded as 34.32 and 24.91°C, respectively (at the early of rainy season) and 33.92 and 18.98°C, respectively (at the end of rainy season). The seed of *V. radiata* cv. Chai Nat 72 were used for 31.25 kg ha^{-1} at different sowing spacings (30×30, 25×50 and 50×50 cm). Chemical fertilizer (12-24-12 kg NPK) was applied at rates of 156.25 kg ha^{-1} at 14 days after planting and 1 month after planting.

Field experiment: The study was laid out in a Randomized Complete Block Design (RCBD) with four replications of across sites. Three sowing spacing (30×30, 25×50 and 50×50 cm) were used to compare the growth and yield components of *V. radiata* cv. Chai Nat 72[11]. Four to five seeds of *V. radiata* cv. Chai Nat 72 were drilled in sub-trial plots, size 5×5 m. Thinning to two plants per hole was carried out by hand at 14 days after planting. Weed control was affected by hand weeding at 1 month after planting. The germination percentage was measured at 14 days after planting. Mungbean growth and development were measured at flowering and harvesting stages.

Statistical analysis: An analysis of variance was conducted on data obtained for each parameter in each treatment. All analyses were carried out using Statistix software, version 8.0. Least Significant Differences (LSD) were calculated at a significance level of 0.05 to test for significant differences among treatments.

RESULTS AND DISCUSSION

Growth and development of *V. radiata* cv. Chai Nat 72 at the flowering stage: There was a significant interaction between a row and plant spacing for the plant height (Table 1) at the early of rainy season. While there was no influence of row and plant spacing on germination percentage, leaf sets a number, leaf area, root length, nodule number and biomass of leaf, stem and root weight. The highest plant height (59.53-62.64 cm) was observed in 50 and 30 cm row spacing, where plants were spaced 25 and 30 cm within rows respectively, while minimum plant height (54.24 cm) was for

50 cm row spacing where plants were spaced 50 cm (Table 1). The probable reason for the maximum in 50 and 30 cm row spacing could be intra row competition of plants for the light that results in tall plants if plants space narrow, while in case of 50×50 cm plants were uniformly distributed. The growth components were not significantly different at the end of the rainy season (Table 2).

Maximum and Minimum biological yield is not significantly different in both seasons compared to the other treatments. Biological yields i.e. number of leaf sets, leaf area, root length, number of nodules, dry weight of leaf, dry weight of stem and dry weight of roots were significantly affected by the sowing season (Table 1 and 2). The row spacing of 30 cm tend to produce higher biological yield of *V. radiata* cv. Chai Nat 72 at the early of the rainy season compared to the row spacing of 50 cm (Table 1). Similar to Ihsanullah *et al.*[12] who reported higher biological yield at a narrow row spacing of 30 cm spaced rows produced a significantly higher biological yield of 5,204.45 kg ha^{-1} and minimum biological yield of 1,727.20 kg ha^{-1} was recorded for row spacing of 50 cm. The early of rainy season sown tend to produce significantly maximum and minimum biological yield of *V. radiata* cv. Chai Nat 72 compared to the end of rainy season. The majority of crops can utilize the factors of favorable environment which ultimately influences plants to have more growth and development in mungbean plants[13]. Moreover, with sowing spacing 30×30 cm, *V. radiata* cv. Chai Nat 72 grew rapidly in terms of branches and leaves, resulting in less competition between weeds and crop when the *V. radiata* cv. Chai Nat 72 plants were close (Table 1), inhibiting the germination of weeds. Sowing spacings of 25×50 cm and 50×50 cm produce a larger distance between the rows so the canopy growth of *V. radiata* cv. Chai Nat 72 could only cover the planting area more slowly than the sowing spacing of 30×30 cm; the influence of light increased weed growth and produced more competition between crops and weeds.

Yield components of *V. radiata* cv. Chai Nat 72 at harvest stage: Yield contributing characters viz. pods per plant, seeds per pod, yield per plant and yield per hectare were significantly affected by sowing seasons (Table 3 and 4). The number of pods per plant is the key yield component in

Table 1: Growth and development of *V. radiata* cv. Chai Nat 72 at the early of rainy season

Sowing spacing (cm)	Germination (%)	Plant height (cm)	No. of leaf sets/plant	Leaf area/plant (cm^2)	Root length (cm)	No. of nodule/plant	Leaf dry weight/plant (g)	Stem dry weight/plant (g)	Root dry weight/plant (g)
30×30	97.92	62.64^a	7.99	1,027.4	24.61	204.25	11.33	7.92	4.17
25×50	98.05	59.53^a	7.85	1,051.5	24.85	192.42	11.10	7.74	4.20
50×50	98.11	54.24^b	7.25	804.7	24.24	188.25	10.42	7.02	4.15
p-value	ns	*	ns	ns	ns	ns	ns	ns	ns

ns: Not significantly different, Different letters indicate a significant difference at $p\leq 0.05$*

Table 2: Growth and development of *V. radiata* cv. Chai Nat 72 at the end of rainy season

Sowing spacing (cm)	Germination (%)	Plant height (cm)	No. of leaf sets/plant	Leaf area/plant (cm^2)	Root length (cm)	No. of nodule/plant	Leaf dry weight/plant (g)	Stem dry weight/plant (g)	Root dry weight/plant (g)
30×30	86.57	25.93	4.96	238.19	16.40	25.35	1.33	0.67	0.29
25×50	78.66	25.05	4.77	262.73	16.74	21.85	1.39	0.62	0.29
50×50	88.78	25.44	5.05	305.66	16.73	29.33	1.55	0.76	0.33
p-value	ns	ns	ns	ns	ns	ns	ns	ns	ns

ns: Not significantly different

Table 3: Yield component of *V. radiata* cv. Chai Nat 72 at the beginning of the rainy season

Sowing spacing (cm)	No. of inflorescence/plant	No. of pods/plant	Pod length (cm)	No. of grains/pod	100 grains weight (g)	Grain yield ha^{-1} (kg)	Harvest index
30×30	12.24	8.22	9.73	10.48	9.90	1,105.13	0.09
25×50	17.30	7.95	9.79	10.55	9.69	890.06	0.10
50×50	20.62	8.99	9.35	10.04	9.67	493.69	0.09
p-value	ns	ns	ns	ns	ns	ns	ns

ns: Not significantly different

Table 4: Yield component of *V. radiata* cv. Chai Nat 72 at the end of the rainy season

Sowing spacing (cm)	No. of inflorescence/plant	No. of pods/plant	Pod length (cm)	No. of grains/pod	100 grains weight (g)	Grain yield ha^{-1} (kg)	Harvest index
30×30	3.11	7.11	7.95	8.54	7.77^a	447.25	0.28
25×50	3.10	6.81	7.75	8.53	7.21^b	251.63	0.39
50×50	3.03	6.43	8.08	8.45	7.69^{ab}	296.00	0.34
p-value	ns	ns	ns	ns	*	ns	ns

ns: Not significantly different, Different letters indicate a significant difference at $p\leq 0.05$*

leguminous crops. The result shows that plants need uniform distribution for a maximum of pods per plant. The inter-row and interplant spacing less than optimum results in competition for nutrients and light. Effect of plant and row spacing was not significant for a number of pods per plant, pod length, number of grains per pod, 100 grain weight and harvest index (Table 3 and 4) in both seasons. As the results of Silva *et al.*[14] reported that pod length, a number of grains per pod and 100-pod weight were not influenced by row spacing and number of plants per meter. There was the influence of significant interaction between the factors studied on 100 grains weight and final plant population. Grain yield showed a decreasing trend due to an increase in sowing spacing.

Grain weight is a variable of high importance since it is generally used to calculate sowing density and to evaluate seed quality, maturity and health. Therefore, this increase in grain weight in response to the increase in population density becomes interesting because it is a characteristic related to its vigor. Sowing spacing of 30 x 30 cm tended to promote higher density and grain yield (1,105.13 kg ha^{-1}) in *V. radiata* cv. Chai Nat 72 at the early of rainy season (Table 3), followed by the use of 25$\times$50 cm spacing. Similar results to Kabir and Sarkar[15] who found that the highest grain yield (1,046.0 kg ha^{-1}) was obtained at 30$\times$10 cm spacing followed in order by 20$\times$20 cm and 40$\times$30 cm spacing. 100-grain weight (Table 4) was significantly higher (7.77 g) than all other row spacing. These results are supported by Board *et al.*[16], who reported that narrow spacing resulted in higher grain yields in food legumes. Ihsanullah *et al.*[12] reported that pod length is a genetically controlled parameter and is less affected by the changes in the microenvironment.

The increased competition caused in the denser populations has a direct effect on the yield capacity of the plants. El Naim and Jabereldar[17] reported that, in high populations, there is a direct effect on the yield capacity of the plant through the number of inflorescences and flowers per plant. Several authors claim that the number of pods per plant is the yield component most affected by increasing plant density[7-9]. In addition, the economic yield of *V. radiata* cv. Chai Nat 72 was reduced at the end of the rainy season and seed size was also smaller than that from the early of rainy season (Table 4). Although the harvest index at the end of rainy season appeared to be higher than at the early of rainy, if lower rates of photosynthesis occur the efficiency of the photosynthetic distribution will affect economic yield as well. Previous researches reported that reducing the distance between planting rows of soybean will increase the number of plant notes and grain yield[18-19].

However, when comparing growth characteristics in both seasons, growth and yield components of *V. radiata* cv. Chai Nat 72 higher at the early of rainy season than at the end of rainy season. Water may not be a limiting factor for the growth and yield components. Because the experiment was installed under an irrigation system. Growing *V. radiata* cv. Chai Nat 72 at the end of rainy season, light duration and light intensity may affect growth, inflorescence number and fertility.

CONCLUSION

Under the conditions studied, to produce mungbean cv. Chai Nat 72, the sprinkler irrigation system should be used in the dry season (at the end of rainy season) in order to mitigate the shorter day length and lower light intensity. Sowing spacing between 30$\times$30, 25$\times$50 and 50$\times$50 cm did not affect the yield components of *V. radiata* cv. Chai Nat 72. The optimum sowing spacing was 30$\times$30 cm which yielded 1,105.13 kg ha^{-1} of grain. In future studies, to increase the potential yield of the mungbean cultivars is approximately 1.5-2.5 t ha^{-1}, narrower sowing spacing of *V. radiata* cv. Chai Nat 72 should be added, such as 20$\times$20, 25$\times$25 and 25$\times$30 cm, to increase the economic yield.

SIGNIFICANCE STATEMENT

This study discovered the possible synergistic effect of sowing season and spacing that can be beneficial for growth and development of *V. radiata* cv. Chai Nat 72. This study will help the researcher to uncover the critical areas of increasing grain yield of *V. radiata* cv. Chai Nat 72 that many researchers were not able to explore. Thus a new theory on narrower sowing spacing with suitable sowing season may be arrived at.

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