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Effect of plant spacing on yield and rust disease incidence of Yardlong bean (*Vigna unguiculata* Sub sp. *Sesquipedalis*) in Southren transitional zone of Karnataka

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Abstract
The present study was carried out during *kharif* 2016 and 2017 to determine the effect of plant spacing on pod yield and incidence of rust disease (*Uromyces vignae*) in Yardlong bean. The treatments includes eight level of spacing (45x30 cm, 45x45 cm, 45x60 cm, 45x75 cm, 60x30 cm, 60x45 cm, 60x60 cm and 60x75 cm) arranged in randomized complete block design with three replications. Two years pooled data revealed that, the pod yield of Yardlong bean was significantly affected by the interaction of spacing and disease incidence. Significantly higher (15.04 t/ha) and lower pod yields (9.39 t/ha) were recorded with the closer spacing of 45x30 cm and wider spacing of 60x75 cm respectively. Correspondingly, the higher rust incidence (61.64%) was observed in closer spacing (45x30 cm). Whereas, the lower disease incidence of 33.86 per cent was noticed with wider spacing (60x75 cm). Even though higher disease incidence noticed in narrow spacing but the yield was highest due to higher plant population and it shows that pod yield per unit area depended not only on the performance of individual plant and severity of disease but also on the number of plants per unit area.

Keywords: spacing, rust, yardlong bean, yield

Introduction
Yardlong bean *(Vigna unguiculata* sub sp. *sesquipedalis)* is a legume cultivated for its nutrious pods. It is originated in West Africa and most widely grown in the warmer parts of South-East Asia, Southern China and India. Nowadays, the area under this crop is increasing under protected as well as in open condition. Though it has got high yield potentiality the actual yield of this crop is low due to following inappropriate spacing. The plant density and arrangement of plants in a unit area greatly determines (i) resource utilization such as sunlight, nutrients and water (ii) the rate, extent of vegetative growth and development of crop (iii) yield components (iv) invasion of diseases and pests. Despite its significance, Yardlong bean production is greatly affected by many foliar diseases including rust. Rust disease caused by *Uromyces vignae* is a major disease of Yardlong bean. Rust occurs worldwide, reaching high severities in cool and humid environments (Pamela *et al.*, 2014) [10]. It occurs widely in India, causing an estimated yield loss to an extent of 20-30 per cent. Long distance dissemination of rust inoculum is mainly by wind (Aylor, 1990) [2]. However, short distance dissemination may occur through contaminated farm implements, clothing and insects. Generally, rust can be controlled using fungicides, resistant varieties, biological control and cultural practices such as intercropping, crop rotation, optimum plant spacing and use of soil amendments that promote soil health and plant nutrition. Further, site-specific cultural practices *viz*., sowing date, suitable variety, sowing date, optimum spacing etc. influence the yield characteristics and quality parameters of bean. But there is no recommendation about the optimum plant population per unit area in cultivation of Yardlong bean. By considering the above constraints, research was conducted to determine the effect of plant spacing on pod yield and diseases incidence of Yardlong bean under the Southren Transitional Zone of Karnataka**.**

Materials and Methods
The experiment was conducted to optimize the plant population for higher productivity in Yardlong bean under field conditions during the main cropping season of *Kharif* 2016 and 2017 at Zonal Agricultural and Horticultural Research Station (ZAHRS), Shivamogga, Karnataka. The experiment was laid out in randomized complete block design with three replications. The experiment consisted of eight spacing treatments (45x30 cm, 45x45 cm,

45x60 cm, 45x75 cm, 60x30 cm, 60x45 cm, 60x60cm, 60x75 cm). The variety Arka Mangala which was released from IIHR, Bangalore was used. The inputs supplied and cultural operations were carried out as per the recommendation for the crop (Anon., 2013) [1].

The percent disease incidence and yield were recorded. The intensity of disease was calculated by 0-9 scale given by Mayee and Datar, 1986 (0 = No pustules; 1 = 1-10% leaflet area covered with rust pustules; 3 = 11-25%; 5 = 26-50%; 7 = 51-75%; 9 = > 75% leaflet area covered with rust pustules). The per cent disease index (PDI) was estimated with the above scales by using Wheeler's (1969) formula.

$$PDI = \frac{\text{Sum of numerical values grades}}{\text{Number of plants observed x Maximum disease rating}} \times 100$$

The data was subjected to statistical analysis by adopting Fisher's method of analysis of variance as outlined by Gomez and Gomez (1984) [7]. The critical difference (CD) values are given at five per cent level of significance, wherever the 'F' test was significant.

Results and Discussion

Effect of plant spacing on disease incidence

Findings revealed that interaction of rust incidence and spacing showed significant results (Table 1). During *Kharif* 2016, the highest rust incidence (57.14%) noticed with the lower spacing of 45x30 cm. The disease incidence increases due to higher plant densities which provide favourable condition for development of disease. Furthermore, Bose *et al.* (2002) [3] and Essubalew *et al*. (2015) [6] confirmed that the rust infection on green bean particularly severe at high humid condition. Similar trend was observed during *Kharif* 2017 where the rust incidence was varied from 37.13 to 66.13 per cent. The maximum rust incidence (66.13%) was recorded with 45x30 cm spacing followed by 45x45 cm (56.29%) while, the minimum (37.13%) was observed with 60x75 cm (Table 1). This is due to the higher plant density in lesser spacing and also the cool and wet environmental condition during the crop period. The pooled analysis of 2016 and 2017 data revealed that the rust disease incidence was ranged from 33.86 to 61.64 per cent. The plant spacing at 45x30 cm resulted in the maximum disease incidence (61.64%). Conversely, the lowest disease incidence was obtained in plants spaced at 60x75 cm (Table 1).

Table 1: Effect of spacing on rust disease incidence and yield of Yardlong bean

Spacing	Rust incidence (%)			Yield (t/ha)		
	2016	2017	Pooled	2016	2017	Pooled
45x30 cm	57.14 (49.13)*	66.13 (54.44)	61.64 (51.79)	15.31	14.77	15.04
45x45 cm	51.61 (45.95)	56.29 (48.64)	53.95 (47.29)	12.00	11.64	11.82
45x60 cm	44.28 (41.74)	53.07 (46.78)	48.67 (44.26)	11.04	10.60	10.82
45x75 cm	41.03 (39.85)	47.35 (43.50)	44.19 (41.68)	9.83	9.50	9.67
60x30 cm	39.59 (39.01)	47.78 (43.75)	43.69 (41.38)	13.46	12.92	13.19
60x45 cm	36.00 (36.89)	44.67 (41.96)	40.34 (39.42)	14.48	14.10	14.29
60x60 cm	35.51 (36.59)	41.82 (40.31)	38.66 (38.45)	11.37	10.99	11.18
60x75 cm	30.59 (33.58)	37.13 (37.56)	33.86 (35.57)	9.69	9.10	9.39
SE.m±	0.43	0.39	0.29	0.44	0.32	0.37
CD @5%	1.29	1.17	0.89	1.32	0.98	1.13
CV(%)	1.83	1.50	1.20	6.23	4.72	5.43

Note: *Figures in parenthesis are arcsine transformed values.

Effect of plant spacing on yield

Plant spacing had significant effect on the yield and it was observed that significantly higher pod yield was recorded with the closer spacing of 45x30 cm as against the lower yield with the wider spacing of 60x75 cm. During *Kharif* 2016, higher pod yield at higher planting density of 45x30 cm (15.31 t/ha) and 60x45 cm (14.48 t/ha) which were found on-par followed by 60x30 cm (13.46 t /ha). The lowest yield was recorded in 45x75 cm and 60x75 cm (9.83 and 9.69 t/ha). During *Kharif* 2017 also similar trend in yield was observed. Highest pod yield of 14.77 and 14.10 t /ha recorded in 45x30 cm and 60x45 cm respectively. Which were on par with each other and which is followed by 60x30 cm (12.92 t/ha). Further, wider spacing recorded the lowest yield of 9.50 and 9.10 t/ha in 45x75 cm and 60x75 cm spacing respectively, this perhaps due to the large number of plants per unit area under narrow spacing which limited the unnecessary vegetative growth and favoured setting of more pods. Samih (2008) [11] showed that higher yield with high plant populations compared to low densities. Cutcliffe (1967) [4] also reported yield of green beans increased at the narrow spacing than the wider spacing. Wahab (1986) [13] stated that higher planting densities of green bean gave higher pod yield per unit area than that of lower planting densities.

Pooled data of 2016 and 2017: The pooled data of two years (*Kharif 2016* and 2017) revealed similar trend in yield. The maximum pod yield of 15.04 t/ha and 14.29 t/ha was recorded with closer spacing of 45x30 cm and 60x45 cm and which were on par with each other followed by 60x30 cm (13.19 t/ha). The minimum pod yield of 9.67 and 9.39 t/ha were recorded with 45x75 cm and 60x75 cm, respectively. In wider spacing the plant population decreased and failed to compensate the loss of increase due to lesser population, though the higher yield per plant was obtained. This might be due to higher plant population per unit area at narrow spacing. Similar findings have been reported by Jakusko *et al.* (2009) [8], Deka *et al.* (2015) [5] and Satodiya *et al.* (2015) [12]. The increment in pod yield at closer spacing might be ascribed to the increase in plant population per unit land area, while the decrease in pod yield at wider intra-row spacing could be associated with decreased plant population per unit land area. It can thus be explained that the pod yield per unit area depends not only on the performance of individual plants but also on the number of plants per unit area as confirmed in this study.

Conclusion

The present study indicated that Yardlong bean grown with spacing of 45x30 cm resulted in the highest total pod yield as

compared to wider spacings. Eventhough higher disease incidence was noticed in narrow spacing but the yield was highest due to higher plant population. It can thus be explained that the pod yield per unit area depended not only on the performance of individual plants and severity of disease but also on the number of plants per unit area. So the optimum spacing can be used as ideal method to manage the rust disease and to maximize pod yield of Yardlong bean.

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