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Full Length Research Paper

Impact of sowing date and plant spacing on yield, quality and disease incidence of Snap bean (*Phaseolus vulgaris l.*) varieties at Jimma Southwestern, Ethiopia

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The present study was carried out to determine the effect of sowing date and plant spacing on pod yield, quality parameters and incidence of major diseases in the field of green bean varieties under humid tropical conditions of Jimma southwestern, Ethiopia. The treatments were five level of spacing (50 cm x 7 cm, 40 cm x 15 cm, 40 cm x 10 cm, 40 cm x 7 cm, 30 cm x 15 cm); four level sowing date (July 3rd, July 18th, August 2nd and August 17th) and two varieties (Melka-1 and Melka-5) in a factorial combination of three factors arranged in randomized complete block design with three replications. Pod yield, quality of green bean (snapping nature, tenderness, straightness and fibreless nature) were significantly affected by the interaction of variety, time of sowing and spacing. The highest total pod yield was obtained due to sowing on the 3rd of July. Highest value of 1.139 and 1.924 due to time of sowing was recorded on quality of green bean in snapping nature and tenderness, respectively at July 3. Similarly, the relative value of variety Melka-1 showed highest (1.780) on quality of green bean (tenderness) as compared to Melka-5 (1.506). Furthermore, the highest (1.566) average value on the straightness of green bean was recorded when the crop grown at 3rd July with spacing of 50cm x 7cm. However, the incidence of major diseases (rust, angular leaf spot and floury leaf spot) generally affected by sowing time. The highest (33.78%) and (24.55%) were recorded of angular leaf spot and floury leaf spot, respectively due to sowing date at August 2nd and July 18th. Early sowing of green bean (3rd July), narrow spacing (40 cm × 7 cm) and variety Melka-1 had a potential to increase the yield, quality and less disease incidence green bean under Jimma condition.

Keywords: Green bean, plant spacing, sowing date, pod yield, pod quality, diseases incidence

INTRODUCTION

Green bean is one of the most cultivated leguminous vegetables in the world, and it is the most important food legume. The annual production of green beans in the world covers an area of greater than 960,272 ha with a total production of 6,814,403 tones currently, the total area coverage of green bean in Ethiopia is above 15,379 hectare with an average total production of 6803 tones (FAO, 2009). It has been among the most important and highly prioritized crop as a means of foreign currency

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earning in Ethiopia (Gezahegn and Dawit, 2006). Besides, green bean has been considered as an important protein supplement in cereals and root crops based food habit in the country and it serves as a green vegetables and it provides protein, calories, vitamins and minerals such as calcium, phosphorus, iron (Lemma, 2003). The major production constraints under Ethiopian conditions includes given the minimum genotype screening undertaken across different climatic zones, the genotype entries had not been consistent, diseases and pests were higher with rain-fed varietals screening than with those under irrigated conditions, when no crop protection measures were taken and high post-harvest losses (Lemma, 2003).

Furthermore; site-specific factors, such as cultural practices and sowing date influence yield, yield characteristics and quality parameters of green bean. Therefore, selection of the most suitable variety, determining suitable sowing date and applying appropriate cultural practices are very important for increasing quality and yield of green bean. Among the various factors, optimum sowing date and best variety are of primary importance to obtain potential yield (Amanullah *et al*., 2002). Considering the above constraints, various variety trails and agronomic experiments in Ethiopia have been carried out on specific planting density under rain-fed and irrigated conditions (Godfery *et al*., 1985). Therefore, a standard spacing of 40 cm x 10 cm has been adopted; irrespective of the growing conditions and locations which was not clear how this spacing was considered as the standard spacing without having planting density study including number of plants per hill. Disease incidence is also one of the major problems being occurred during with regard to plant spacing and sowing date for instance angular leaf spot incidence is high humidity and the as the temperature ranges between 16-28^{0}C (Hagedorn and Inglis, 1986). In Ethiopia, particularly in Jimma zone, there has not been green bean production both at small scale and commercial farmers mainly due to lack of appropriate varieties, lack of information on time of sowing and spacing to be used (Lemma, 2003). Therefore, the research was conducted to determine the effect of sowing date and plant spacing on pod yield, quality and diseases incidence of snap bean varieties under the humid tropical conditions of Jimma, Southwest Ethiopia.

MATERIALS AND METHODS

Description of the Experimental site

The experiment was conducted Jimma University College of Agriculture and Veterinary Medicine experimental station at Eladalle during the main cropping season under rain-fed condition. The experimental site situated at altitude of 1753 m a.s.l. and latitude of 7^0 S 42' 9''N and longitude 36^0 47' 6'' E in Ethiopia. It receives an average annual rainfall of 1,559 mm with maximum and minimum temperatures of 26.8 and 13.6 ^{0}C, respectively. The average maximum and minimum relative humidity of the area are 67.5 and 37.92 %, respectively. The soil of the experimental site is reddish brown clay classified as Nitisol with pH range of 5.0 to 6.0 (BPEDORS, 2000).

Experimental Design and Treatment

Two green bean varieties (Melka-1 and Melka-5) obtained from Melkassa Agricultural Research Center, were used for the research**.** The experiment consisted of three factors, five levels of inter-row and intra-row spacing (50 x 7 cm, 40 x 15 cm, 40 x 10 cm, 40 x 7 cm, 30 x 15 cm), with four levels of time of sowing (July 3rd, July 18th, August 2nd, and August 17th, 2010) and two green bean varieties (Melka-1 and Melka-5) arranged in 5 x 4 x 2 factorial in randomized complete block design with three replications. The spacing levels were determined bearing in mind the national recommendation as reference (40cmx10cm). There were four rows in each plot that were spaced differently as per the respective treatments. The spacing between plots and blocks was 0.5 and 1 m, respectively. The first sowing was on the 3rd of July, 2010 and subsequent sowings for the other treatments were conducted at 15 days interval. Any required field management practices were performed as per recommended for the crop (Lemma, 2003).

Data Collected and Analysis

Data on the yield, diseases incidence and quality parameters of green bean were recorded from middle two rows of each plot. These quantitative data includes disease scoring, snapping nature of the pods 1 to 3 (1=Very-snapping 2=Moderate and 3 =Less snapping), tenderness nature of pods 1 to 3 (1= Very tender (Firm) 2=Moderate and 3=Less tender). Straightness nature of pods 1 to 3 scale (1= Very straight, 2= Slightly curved and 3 = Curved). Finally, fiberlessness was recorded on the basis of 1 to 3 scale (1= Fibreless, 2= Slightly fibrous and 3=Fibrous). Accordingly, the data was subjected to ANOVA using Genstat version 11 (VSN International, 2008) with the REML variance components analysis. Means that showed significant differences were separated using Least Significant Differences (LSD) at 5% level of significance (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Analysis of Variance

There was significant ($P \leq 0.05$) effect of sowing date on the total pod yield (kg ha^{-1}), snapping, tenderness quality nature of green bean and to the incidence of both angular leaf spot and flour leaf spot diseases. The effect of spacing on total pod yield (kg ha^{-1}) and tenderness quality nature of green bean was significant at ($P \leq 0.05$). The varietal difference was found to be significant ($P \leq 0.05$) for total pod yield and tenderness quality nature of green bean (Table 1).

The result presented in Table 1 indicated that the interaction effect of varieties and sowing date was significant ($P \leq 0.05$) for fibreless**,** straightness quality nature and rust disease incidence of green bean. The performance of green bean in-terms of straightness quality nature was significantly ($P \leq 0.05$) influenced by the interaction effects of spacing and sowing date (Table 1).

Effect of sowing date and plant spacing on diseases incidence

Rust Incidence

Findings revealed that rust incidence showed a significant ($P \leq 0.05$) due to interaction of varieties and sowing date (Table 1). The highest rust incidence from the whole treatment combinations was recorded at when Melka-5 sowed in August 2nd whereas the lowest of rust incidence was scored from the interaction between Melka-1 sowed in 17th August (Fig 1). This is due to at the early sowing date the plants expose for more length period of rain fall, humidity and less period of sunlight and another important thing that aggravate the development of diseases. Furthermore, Bose *et al.* (2002) confirmed that the rust infection on green bean particularly severe at high humidity condition.

Angular Leaf Spot Incidence

The effect of sowing date on angular leaf spot diseases incidence percentage showed a significant ($P \leq 0.05$) effect on green bean plant (Table 1). The highest (33.78) angular leaf spot incidence was recorded in 2nd August whilst, the lowest (20.82) angular leaf spot incidence was observed in July 3rd sowing dates (Table 2). This described that at the early sowing date there is relatively high humidity as compared to the other sowing date and the temperature at this month favorable for the growth and development of the disease. Furthermore (Hagedorn and Inglis, 1986) reported that the angular leaf spot incidence become high as humidity increases with the range of temperature 16-28^{0}C.

Floury Leaf Spot Incidence

The result revealed that floury leaf spot incidence also significantly ($P \leq 0.05$) affected by different sowing dates of green bean (Table 1). The maximum (24.55%) floury leaf spot incidence was recorded in 18th July while, the minimum (19.43%) floury leaf spot incidence percentage was observed in 17th August (Table 2). This is due to the diseases more sever at the cool and wet environmental condition than warm condition. Hagedorn and Inglis (1986) confirmed that cool and wet weather condition and in which the leaves remain wet for periods of 24 hours and longer period of time are essential for the growth and development of the diseases. Furthermore: floury leaf spot incidence was severing at under cool temperature and high relative humidity (CIAT, 1981).

Effect of sowing date and plant spacing on physical quality parameters

Snapping Nature of green bean

The different sowing date showed significant ($P \leq 0.05$) effects on the snapping quality nature of green bean (Table 1). From the whole sowing date, sowing of green bean in July 3rd showed the most (1.139) snapping quality nature of green bean. While, green bean sowed in 17th August showed the least (1.007) snapping quality of green bean followed by sowing snap bean at August 2nd(Table 3).

Tenderness (Firmness) of green bean

The findings indicated that variety, sowing date and spacing showed significantly and independently ($P<0.05$) affected tenderness (Firmness) quality nature of green bean (Table 1). Significantly more (1.924) tenderness (Firmness) quality nature of green bean was observed at green bean sowed in July 3rd and significantly the least (1.291) tenderness (Firmness) quality was observed in 17th August (Table 3). However, there was significant interaction ($P<0.05$) effect on variety, sowing date and spacing on the tenderness quality of green bean (Table 1). The effect of different spacing showed significant ($P<0.05$) difference on the tenderness quality of green bean. The highest (1.708) tenderness quality was observed on a green bean sowed at 50cmx7cm, whilst the lowest (1.595) tenderness quality was observed sowing of green bean at the in all spacing of except 40cmx7cm (Table 4).

The result revealed on Table 5 that tenderness quality of variety Melka-1 significantly higher (1.780) compared to Melka-5. The difference between the two varieties used for the study in respect of tenderness quality could mainly be due to the genetic makeup difference of the

Table 1 Mean square error for the studied traits

Traits	Variety	Spacing	Sowing date	Variety* Spacing	Variety* Sowing date	Spacing*Sowing date	Variety* Spacing* Sowing date
TPY	4.51*	6.86*	146.76**	3.49^{ns}	0.56^{ns}	20.93^{ns}	15.00^{ns}
FL	0.19^{ns}	4.03^{ns}	20.20**	4.66^{ns}	8.77*	16.05^{ns}	(3.42^{ns}
SN	0.52^{ns}	4.79^{ns}	11.74*	2.12^{ns}	2.59^{ns}	22.77^{ns}	3.88^{ns}
TE	28.64**	27.83**	152.32*	2.19^{ns}	7.93^{ns}	6.11^{ns}	17.91^{ns}
ST	12.12**	3.40^{ns}	31.73**	5.70^{ns}	9.66*	29.35*	14.83^{ns}
RUST	1.49^{ns}	1.61^{ns}	41.38**	2.78^{ns}	8.50*	9.97^{ns}	17.25^{ns}
ALS	0.70^{ns}	5.86^{ns}	226.46**	2.79^{ns}	3.49^{ns}	11.95^{ns}	7.56^{ns}
FLS	0.73^{ns}	1.01^{ns}	74.49**	2.52^{ns}	0.88^{ns}	7.71^{ns}	7.74^{ns}

NB *TPY: Total Pod Yield, FL: fibreless, SN: Snapping, TE: Tenderness, ST: Straightness, RUST: Rust Incidence, ALS: Angular Leaf Spot Incidence and FLS: Floury Leaf Spot Incidence*

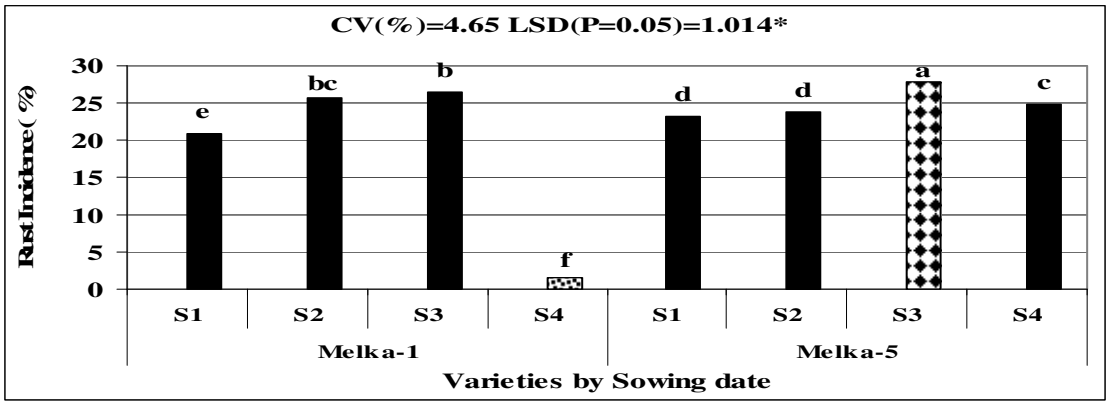

Figure 1 Interaction effect of varieties and sowing date on rust incidence (%) in green bean

Table 2 Effect of sowing date on angular leaf spot and floury leaf spot incidence (%) of green bean

Sowing date	Angular leaf spot incidence (%)	Floury leaf spot incidence (%)
July 3rd	20.82^{d}	21.00^{b}
July 18th	30.33^{c}	24.55^{a}
August 2nd	33.78^{a}	20.38^{c}
August 17th	32.99^{b}	19.43^{d}
CV (%)	2.09	1.89
LSD (P=0.05)	0.615	0.404

two varieties. The observed difference in fresh pod yield between the two varieties of green beans owing to their genetic makeup Lemma *et al.* (2006).

Straightness of green bean

The interaction between spacing and sowing date

Table 3 Effect of sowing date on snapping nature, tenderness quality of green bean

Sowing date	Snapping Nature (1 to 3 scale)*	Tenderness (Firmness) (1 to 3 Scale)**
July 3rd	1.139[a]	1.924[a]
July 18th	1.087[b]	1.846[b]
August 2nd	1.037[c]	1.511[c]
August 17th	1.007[d]	1.291[d]
Mean	1.068	1.643
CV (%)	1.645	4.22
LSD (P=0.05)	0.017	0.069

*= ***Snapping Nature (1**=Very-snapping, 2= Moderate and 3= Less snapping)*
= ***Tenderness (1=Very tender, 2= Moderate and 3= Less tender)*

Table 4 Effect of plant spacing on tenderness (Firmness) quality of green bean

Spacing	Tenderness (Firmness) (1to3 Scale)**
50cmx7cm	1.708[a]
40cmx15cm	1.625[b]
40cmx10cm	1.647[b]
40cmx7cm	1.595[b]
30cmx15cm	1.641[b]
Mean	1.643
CV (%)	5.79
LSD (P=0.05)	0.095

Table 5 Effect of varieties on tenderness (Firmness) quality of green bean

Varieties	Tenderness (Firmness) (1to3 Scale)**
Melka-1	1.780[a]
Melka-5	1.506[b]
Mean	1.643
CV (%)	3.67
LSD (P=0.05)	0.060

showed significant ($P \leq 0.05$) effects in the straightness nature quality of green bean (Table 1). Therefore, the highest (1.566) straightness nature quality of green bean was observed when the green bean sowed in July 3rd at 50cmx7cm. The lowest (1.110) straightness quality nature of green bean was observed in August 2nd at 50cm x 7cm (Table 6).

Interaction effects of variety and sowing date on quality parameters of green bean

Straightness nature of green bean

The straightness nature quality of green bean significantly ($P<0.05$) affected due to varieties and sowing date (Table 1). The highest (1.464) straightness nature quality was observed from Melka-5 sowed in July 3rd while the lowest (1.162) straightness quality of green bean was recorded in August 2nd for Melka-1 (Table 7).

Fibreless Nature of green bean

The interaction effect between variety and sowing date showed significant ($P \leq 0.05$) difference in the fibreless nature of green bean (Table 1). The highest fibreless nature quality of green bean was observed from the interaction between Melka-1 with sowing date in 3rd July (Table 8). This result agreed with the work of Marlene *et al* (2008) as reported the delay sowing of green bean such as unsuitable weather conditions, they resulted the

Table 6 Interaction effect of plant spacing and sowing date on straightness quality of green bean

Parameters		Straightness***
Spacing	Sowing date	
50cmx7cm	July 3rd	1.566[a]
	July 18th	1.147[etg]
	August 2nd	1.110[g]
	August 17th	1.247[det]
40cmx15cm	July 3rd	1.389[bc]
	July 18th	1.278[cde]
	August 2nd	1.130[fg]
	August 17th	1.184[etg]
40cmx10cm	July 3rd	1.389[bc]
	July 18th	1.200[etg]
	August 2nd	1.262[cdet]
	August 17th	1.478[ab]
40cmx7cm	July 3rd	1.351[bcd]
	July 18th	1.161[etg]
	August 2nd	1.397[bc]
	August 17th	1.387[bcd]
30cmx15cm	July 3rd	1.394[bc]
	July 18th	1.280[cde]
	August 2nd	1.247[det]
	August 17th	1.431[ab]
Mean		1.30
CV (%)		9.01
LSD (P=0.05)		0.117

****= Straightness (1= Very straight, 2=Slightly curved, 3=Curved)*

Table 7 Interaction effect of variety and sowing date on straightness quality of green bean

Sowing Date							
Variety	July 3rd	July 18th	August 2nd	August 17th	Mean	CV (%)	LSD (P=0.05)
Melka-1	1.397[b]	1.218[d]	1.162[e]	1.225[d]	1.251		
Melka-5	1.464[a]	1.439[ab]	1.296[c]	1.209[de]	1.352	5.67	0.074
Mean	1.431	1.328	1.229	1.217	1.302		

****= Straightness (1= Very straight, 2=Slightly curved, 3=Curved)*

Table 8 Interaction effect of variety and sowing date on fibreless nature green bean

Sowing Date							
Variety	July 3rd	July 18th	August 2nd	August 17th	Mean	CV (%)	LSD (P=0.05)
Melka-1	1.171[a]	1.036[cd]	1.032[cd]	1.067[b]	1.07		
Melka-5	1.106[b]	1.043[cd]	1.024[d]	1.179[a]	1.07	3.79	0.04

*****= Fibreless nature (1 to 3 Scale) (1= Fibreless,2= Slightly fibrous and 3= Fibrous)*

Table 9 Effect of sowing date on pod yield of green bean plants

Sowing date	Pod Yield (kg/ha)
3rd July	7182[a]
18th July	7000[a]
2nd August	2621[b]
17th August	1818[c]
CV (%)	15.39
LSD (5%)	712.22

Table 10 Effect of plant spacing on total pod yield of green beans

Plant Spacing	Parameters
	PY (kg/ha)
50cmx7cm	4456[b]
40cmx15cm	4362[b]
40cmx10cm	3866[c]
40cmx7cm	5777[a]
30cmx15cm	4817[b]
Mean	4655.6
CV (%)	17.46
LSD (5%)	813.033

Table 11 Effect of varieties on pod yield of green bean

Varieties	Pod Yield (kg/ha)
Melaka-1	4323[b]
Melaka-5	4988[a]
Mean	4655.5
CV (%)	10.986
LSD (5%)	511.560

highest fiber development this might be quality compensate for the pod yield losses.

Effect of sowing date and plant spacing on total pod yield

Total Pod Yield

There was a significant ($P \leq 0.05$) effect of sowing date on total pod yield of green bean (Table 1). Higher pod yield was obtained sowing of green bean on the 3rd of July. On the contrary, the lowest total pod yield was registered from sowing the beans late, the 17th of August (Table 9). This was probably because of the limited vegetative growth of plants from the late sowing as a result of the limited photosynthates availability. This in turn was attributed to the short rains associated with late sowing. Yoldas and Esiyok (2007) revealed that decreased yield due to a short vegetation period of the crop sown late and the maximum growth and yield was obtained by sowing of beans on July. Lower pod yield in the late planting season was due to a smaller biomass production from a shorter vegetative growth period and moreover, the decline in pod production may simply result from declining flower production as vegetative growth ceases. Late sowing has negative consequences on yield because the reproductive stage occurs when weather conditions are less favorable. The reproductive period of common bean plants coincide with the highest summer temperatures and this cause abscission of many buds and flowers that results in a significant decrease in productivity (Marlene *et al.,* 2008).

Plant spacing at 40cmx7cm resulted in the highest pod yield. Conversely, the lowest total pod yield was obtained from a green bean spaced at 40cmx10cm (Table 10). There was a difference of 49.43 percent total pod yield between the maximum and the minimum and this perhaps due to the large number of plants per unit area under narrower spacing which limited the unnecessary vegetative growth and favored setting of more pods. Samih (2008) who showed superior yield in the case of high plant populations over that of low densities. This could be attributed to the less severe competition among plants for nutrients and other resources under the context of less number plants per unit area. Cutcliffe (1967) also

reported yield of green beans increased at the narrow spacing than the wider. Wahab (1986) stated that higher planting densities of green bean gave higher pod yields per unit area than that of lower planting density.

The highest total pod yield was obtained from the variety Melka-5 whereas the lowest total pod yield was obtained from Melka-1 (Table 11). The difference between the two varieties used for the study in respect of total pod yield could mainly be due to the genetic makeup of the varieties. Lemma *et al.* (2006) observed difference in yield between the two varieties of green beans owing to their genetic makeup. The two varieties also manifest differences in respect of earliness and vegetative growth. Cultivars with long vegetative growth duration had generally higher fresh pod yields than those with short vegetative growth duration in the early and normal planting seasons (Marlene *et al.,* 2008). El-Noemani *et al.* (2010) reported that snap bean growth, pods or seed yield and total exportable yield are greatly affected by genotype of variety. Amer *et al.* (2002) concluded that the differences in pods yield of bean varieties might be attributed due to the genetic makeup a variety.

Summery and Conclusion

Choice of appropriate variety, with suitable sowing date and using the optimum plant spacing are very important factors to increase yield, quality as well as reduce disease incidence of green bean. The present study indicated that green bean sowed on the 3rd of July resulted in the highest total pod yield. Similarly, the highest total pod yield was obtained with plants spaced at 40 cm × 7 cm. Among the varieties, Melka-5 gave the highest total pod yield. On the other hand the lowest of rust incidence was scored from the interaction between Melka-1 sowed in August 2nd. The lowest angular leaf spot incidence was observed in July 3rd sowing dates. The minimum floury leaf spot incidence percentage was observed in 17th August. Quality of green bean also affected by different plant spacing and sowing date with different variety. The present funding sowing of green bean in July 3rd showed the most snapping quality nature of green bean. More tenderness (Firmness) quality nature of green bean was observed at green bean sowed in July 3rd. The highest tenderness quality was observed on a green bean sowed at 50cmx7cm. The result revealed that tenderness quality of variety Melka-1 significantly higher as compared to Melka-5. The interaction between July 3rd and 50cmx7cm gives the highest straightness nature quality of green bean. The highest straightness nature quality was observed from Melka-5 sowed in July 3rd and the highest fibreless nature quality of green bean was observed from the interaction between Melka-1 with sowing date in 3rd July.

Therefore, the results of this study has shown that different sowing date, spacing, and varieties had a significant positive influence on the yield, quality and disease incidence of green bean. Hence, sowing of green bean at 3rd July gives more pod yield, more quality green bean and less disease incidence as compared to the other sowing date.

From this study, it can be concluded that sowing of green bean at 3rd July, spacing at 40 cm × 7 cm and variety Melka-1 had a potential to increase the yield, quality and less disease incidence green bean under Jimma condition. Hence, farmers and any new commercial growers and/or investors at Jimma and similar agro-ecology areas can use these packages for growing green bean with better quality and yield.

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