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Research Article

Breeding for evolution of photo-insensitive pole type vegetable dolichos (*Lablab purpureus* L.) varieties to suit year round cultivation

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Abstract
Photosensitivity in pole types of vegetable dolichos is a major production constraint limiting its production to rabi. Presently, the pole type varieties are gaining popularity among farmers because of their higher yield levels. To accomplish the development of high yielding, pole type and photo-insensitive varieties, hybridization was done between (IC 556824-IPS-2 X Arka Swagath) and (IIHR 178 X Arka Swagath), wherein superior transgressive seggregants from both the crosses were selected and crossed with Arka Amogh. Followed by pedigree method of breeding, the lines were advanced upto F_7 generation wherein six advanced breeding lines comprising of photo-insensitive trait, high yield and promising pod characters were selected and evaluated using pole type check varieties during both kharif and rabi for three years in succession from 2015-2017. All the advanced breeding lines had normal flowering in both the seasons as well as outperformed the checks with yield ranging from 37.2 to 41.1 t/ha during kharif and 37.9 to 41.4 t/ha in rabi, whereas in checks yield was comparatively lower ranging from 15.2 to 26.3 t/ha and 17.4 to 26.7 t/ha during kharif and rabi respectively.

Keywords
Pole type, yield, photo-insensitive, kharif, hybridization.

INTRODUCTION

Dolichos bean, *Lablab purpureus* L. Sweet (2n = 22), one of the most ancient crops among cultivated plants is largely cultivated across the tropical regions of Asia and Africa (Rahman *et al.* 2002; Haque *et al.* 2003). In India it is mainly grown in the states of Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh, Uttar Pradesh and North Eastern states. Being a legume vegetable it is recognized as vital source of nutrients, rich in health provoking phytochemicals and equipped with wide spectrum of micronutrients that can have far-reaching impact on fulfilling nutritional and health demands of humankind (Biju *et al.* 2001; Messina, 2016). Botanical varieties of dolichos are categorized into two types *viz., Lablab purpureous* var. *typicus and Lablab purpureus* var. *lignosus* with the former cultivated for its soft, edible pods and consumed as a vegetable whereas the later with dry seeds is largely used as a pulse food. It is a multifaceted crop that can be utilized for vegetable, pulse and fodder purpose (Adebisi and Bosch, 2004). Despite its huge potential, the crop remains unexploited by both farmers and consumers owing to a variety of

reasons that comprise of low yield coupled with longer duration, photosensitive nature of plants and distinctive consumer preferences. Although it is a drought tolerant crop cultivated in dry lands with sparse rainfall, the crop prefers relatively cool season for flowering that starts fruiting in winter due to its photosensitive nature strictly hampering the kharif cultivation (Savitha, 2008; Verma *et al.,* 2014). In India, both bush and pole varieties are grown on a commercial scale with the former being photo-insensitive and grown during both kharif and rabi wherein varieties like Arka Jay, Arka Vijay and Konkan Bhushan are popular but their yields are low with 10-12 t/ha. In disparity to this, pole type varieties are generally indeterminate, high yielding but lack of photo-insensitive trait that makes them absorb for kharif cultivation (Parmar *et al.* 2013). Nevertheless pole varieties such as Swarna Utkrisht, Pusa Early Prolific (PEP) and Arka Swagath with yield potential of 20-30 t/ha imparted with photo-insensitivity are available, there is yet tremendous scope for enhancement of yield in the pole type dolichos varieties. Since, India is

identified to be the centre of origin and primary centre of diversity for dolichos, wide range of variability for various characters especially the yield has been proclaimed that could be tapped for augmenting yield levels of pole dolichos varieties (Mahadevu and Byregowda, 2005; Nene, 2006; Upadhyay *et al.* 2011). Besides this, the consumer preference for dolichos varieties relies considerably with pod shape, size, colour, aroma and cooking quality. Although wide range of varieties in both bush and pole type dolichos are available for commercial cultivation in the market, many of them lack preferable sensory characteristics since breeding programmes rarely attempted towards incorporation of these traits, that often fetch poor market and less preferred by consumers (Shivachi *et al.* 2012). With this background, the present investigation is aimed towards the development of pole type, photo-insensitive, high yielding dolichos varieties that invariably suit for round the year cultivation and also ensemble the choices of different consumer segments.

MATERIALS AND METHODS

The present breeding programme aimed towards the development of high yielding, pole type, photo-insensitive dolichos varieties was started in 2007 at Indian Institute of Horticultural Research, Bengaluru, India (13.13° N, 77.49° E) located at an altitude of 890 m above the mean sea level. Parental lines used in the study comprised of Arka Swagath, IIHR178, IC 556824-IPS-2 (pole type, photo-insensitive genotypes) and Arka Amogh, high yielding photo-insensitive bush variety. Initially, the crosses were attempted separately between (IC 556824-IPS-2 X Arka Swagath) and (IIHR 178 X Arka Swagath) to generate F_1 population. Superior transgressive seggregants in F_2 generation from both the crosses were further selected and crossed with Arka Amogh for imparting superior pod quality characteristics. Following pedigree method of breeding, the selected lines with high yield and superior pod quality characteristics were advanced upto F_6 generation, wherein six high yielding lines with promising pod characters were selected during 2015. These advanced breeding lines were evaluated in Randomized block design with three replications using three pole varieties as checks *viz.,* Arka Swagath (parental high yielding check), Pusa Early Prolific (PEP) and Swarna Utkrisht (non-parental high yielding checks) during kharif and rabi for three consecutive years from 2015-2017 to assess their photoperiodic responses. Recommended horticultural practices and plant protection measures were followed for raising the crop. Data on days to 50% flowering, days to maturity, pod length (cm), pod width (cm), 10 pod weight (g), pods per plant, pod shape, pod color and pod yield (t/ha) were recorded from 10 plants in each of the three replications. Mean data obtained from the observations was subjected to the Analysis of variance (ANOVA) using the GENSTAT 9.1 package to assess significant differences among the breeding lines and checks on the basis of mean performance. Apart from this, the sensory characteristics of the pods in the selected breeding lines was assessed based on the data collected from 30 respondents to analyze the consumer preferences.

RESULTS AND DISCUSSION

Results of ANOVA revealed significant differences among the different advanced breeding lines and the mean values showed wide range of variations for various morphological, yield and yield related traits in the present study (**Table 1**). Days taken for 50% flowering in the lines ranged from 43.7 to 53.0 as compared to checks with 52.7 to 63.5 days. With respect to this trait, early flowering within 43.7 days after sowing was reported in the line IIHR 15-7 followed by IIHR 15-8 with 46.7 days whereas the highest of 53.0 days was recorded in IIHR 15-5. But in case of checks the relative time period taken for 50% flowering is comparatively longer with the highest of 63.5 days in the check variety Swarna Utkrisht. These results clearly delineate that the selected advanced breeding lines were imparted with photo-insensitive nature, evident from the early flowering noticed during unconventional crop growing kharif season and also flowering started from basal node. Further, high heritability coupled with genetic advance has been reported by Verma *et al.* (2014) that supports selection for trait is effective in dolichos breeding programmes. In connection to days to first pod maturity, variability in the lines ranged from 61.6 to 67.0 and in checks it was 61.7 to 83.5 days. This clearly illustrates that the significant differences exist between lines and checks for the two traits *viz.*, days to 50% flowering and days to pod maturity and all the selected breeding lines flowered early and attained pod maturity in advance to the check varieties. Further, it is conspicuous that the selected advance breeding lines generated from the present study assimilated photo-insensitivity nature witnessed on the basis of flowering against the eccentric long day photoperiods. With respect to pod length and width, selected breeding lines had higher pod length ranging from 11.2 to 17.8 cm and width of 1.3 to 3.3 cm in comparison to checks with 10.6 to 11.2 cm and 1.3 to 2.0 cm of pod length and width respectively. In terms of pod length, the highest of 17.8 cm was observed in IIHR 15-21 followed by IIHR 15-15 with 17.5 cm and least of 10.6 cm was found in check Swarna Utkrisht. Similar trend was reported in case of pod width wherein IIHR 15-23 followed by IIHR 15-5 recorded the highest pod width of 3.3 cm and 3.0 cm respectively and the lowest was recorded by check PEP with 1.3 cm. The results obtained are in synchrony with the experimental findings of Magalingam *et al.* (2013), Parmar *et al.* (2013) and Peer *et al.* (2018) who reported a significant and wide range of variability with respect to various morphological traits that are indirectly governing the yield in dolichos bean.

Among traits directly governing yield such as 10 pod weight and the number of pods per plant, significant differences in mean values were observed between checks and selected advanced breeding lines. With respect to 10 pod weight, all the selected lines recorded significantly higher pod weight ranging from 80.3 to 180.3 g as compared to checks with 69.0 to 75.3 g. Highest pod weight of 180.3 g was recorded by IIHR 15-23 followed by IIHR 15-15 with 150.3 g. In addition to this, the number of pods per plant were on the highest side in IIHR 15-7 with 566.7 pods per

Table 1. Mean of pod characters in advanced breeding lines and check varieties during offseason cultivation (kharif) from 2015-2017

Sl. No.	Advanced breeding lines/ checks	Pedigree	Days to 50 % flowering	Days to pod maturity*	Pod length (cm)	Pod width (cm)	10 Pod weight (g)	No. of pods/ plant	Pod shape	Pod color
1.	IIHR 15-15	(IC 556824)-IPS-2 X (Arka Swagath)-IPS 15	47.7	64.7	17.5	2.1	150.3	325.0	Flat, long slightly curved	DG
2.	IIHR 15-5	(Arka Amogh X (IIHR 178) -IPS-5	53.0	67.0	13.8	3.0	140.7	321.7	Medium long undulating with shining surface	G
3.	IIHR 15-23	IIHR 178) X (Arka Swagath)-IPS 23	48.0	64.7	17.0	3.3	180.3	263.3	Flat, long, broad and thick	G
4.	IIHR 15-21	(IIHR178) X (Arka Swagath)-IPS 21	48.3	65.3	17.8	1.3	119.7	369.0	Slender, long undulating	DG
5.	IIHR 15-8	Arka Swagath X (IIHR 178)-IPS 8	46.7	66.7	12.3	2.2	120.7	387.7	Flat, Medium long and slightly broad	G
6.	IIHR 15-7	Arka Swagath X (IIHR 178)-IPS 7	43.7	61.7	11.7	1.7	80.3	556.7	Pods dark green, similar to Arka Swagath	DG
7.	Arka Swagath (PC)	-	52.7	65.3	11.2	1.6	75.3	420.3	Pods light green and medium long	LG
8.	Pusa Early Prolific (NC)	-	58.8	75.5	10.9	1.3	68.7	78.0	Flat, medium long pods	DG
9.	Swarna Utkrisht (NC)	-	63.5	83.5	13.1	2.2	71.7	89.4	Flat, medium long pods	G
	S.E.(m)±	-	0.99	1.18	0.51	0.10	2.06	11.34	-	-
	CD @ 5 %	-	2.73	3.27	1.43	0.27	5.71	31.43	-	-
	CV %	-	2.86	2.58	5.03	6.45	2.36	4.25	-	-

*Days for first picking
PC-Parental Check, NC-Non parental Check
G-Green, DG-Dark Green, LG-Light Green

plant and the lowest of 263.3 pods per plant were found in IIHR 15-23 among the breeding lines. Elsewhere, in the checks wide range of variability was recorded for the trait with 76.5 to 420.33 pods per plant and among the three checks used, Arka Swagath and PEP recorded the highest and lowest number pods per plant respectively. Specific to this trait, out of the six selected breeding lines, only one line IIHR 15-7 yielded more number of pods per plant than the parental check Arka Swagath whereas others had lower number of pods per plant than this check and ranged from 263.3 to 387.7. Nevertheless all the six lines recorded more number of pods per plant in examination to the other two non-parental checks. Although parental check is performing superior in relation to this trait, yield was steeping in breeding lines owing to their expansion in pod weight than the check varieties. The outcome obtained from this study is in harmony with the findings of Desai *et al.* (2003), Parmar *et al.* (2013), Magalingam *et al.* (2013) and Radhelal *et al.* (2018) who reported direct correlation and significant positive direct effects between pod weight and pod yield in dolichos bean. Consistent

with the results, significant positive and direct correlation between pod length, pod width, pod weight and pods per plant with pod yield in vegetable dolichos has been reported by Gupta *et al.* (2017).

Further, the comparison of yield *per se* between checks and selected breeding lines based on the average of three years during kharif and rabi unveiled significant differences between checks and breeding lines with selected lines ascendant over the three check varieties (Table 3). Average pod yield based on mean of four years during kharif in selected lines ranged from 37.2 to 41.1 t/ha in selected lines, based on the average of six pickings and in checks it was significantly lower with 15.2 to 26.3 t/ha. Among the six advance breeding lines, the highest yield of 41.1 t/ha was reported in IIHR 15-15 followed by IIHR 15-23 with 40.4 t/ha (Table 2). In rabi, average yield over three years ranged from 37.9 to 41.4 t/ha and in checks the yield levels remained almost similar to mean yields recorded during kharif ranging from 17.4 to 26.7 t/ha. In conjunction to this, percent increase in yield over

Table 2. Mean pod yield (t/ha) of selected advanced breeding lines and checks during kharif and rabi from 2015-2017

S. No.	Advanced breeding lines/ checks	2015		2016		2017		Mean[*]		Percent increase in yield over parental check	
		Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
1.	IIHR 15-15	41.1	41.4	39.9	41.9	40.9	40.9	40.7	41.4	54.7	55.2
2.	IIHR 15-5	37.6	38.6	37.7	39.3	37.5	39.1	37.6	39.0	43.2	46.1
3.	IIHR 15-23	39.2	40.2	39.0	40.7	40.2	40.7	39.5	40.5	50.2	51.9
4.	IIHR 15-21	36.6	38.1	37.1	38.7	37.0	37.0	36.9	37.9	40.4	42.1
5.	IIHR 15-8	38.5	40.3	38.8	40.8	39.2	39.1	38.8	40.1	47.8	50.1
6.	IIHR 15-7	37.0	38.3	36.8	38.7	37.4	38.8	37.1	38.6	41.1	44.6
7.	Arka Swagath (PC)	26.6	26.5	26.3	26.7	25.9	26.8	26.3	26.7	-	-
8.	Pusa Early Prolific (NC)	16.5	18.2	14.4	17.4	14.8	16.5	15.2	17.4	-	-
9.	Swarna Utkrisht (NC)	24.6	22.4	23.4	25.8	21.9	24.6	23.3	24.3	-	-
	S.E.(m)±	0.82	0.84	1.04	0.86	0.99	1.13	-	-	-	-
	CD@5%	2.27	2.33	2.88	2.39	2.76	3.13	-	-	-	-
	CV %	3.16	3.16	4.03	3.20	3.82	4.27	-	-	-	-

*In six pickings

the parental check ranged from 42.5 to 57.5 t/ha during kharif and in rabi, it varied between 42.1 to 55.2 t/ha wherein the line IIHR 15-15 outyielded all other breeding lines inclusive of non-parental checks across both the seasons. The reason behind momentous improvement in yield in the breeding lines could be accounted to a blend of factors that include heterotic advantage, alterations in genetic architecture, photo-insensitivity and induction in flowering that started from the basal node of the plant. The results generated from the study are in congruity with the findings of Kambale *et al.* (2002), Patil and Lad (2007), Chattopadhyay and Dutta (2010) and Verma *et al.* (2014) who explored wide range of variability for various traits governing yield and also yield *per se* from their studies. As accentuated earlier consumer preferences for vegetable type dolichos diverge extensively based on sensory characters such as appearance, texture, taste and cooking quality of pods. Hence, the selections were made

consciously before advancing breeding lines that befit the requirements of different consumer segments. The selected advanced breeding lines are not only contrasted for pod yield but also were distinct in terms of appearance and texture as indicated in table 1. In the present study, respondents had the highest preference for line IIHR 15-15 as apparent from its highest mean score of 95.6 and least of 91.5 was recorded in IIHR 15-8 (Table 3). Hence, all the breeding lines being morphologically distinct and heterogeneous, not only satisfy the specifications of different consumer segments but also assist the farmers to avoid mechanical mixtures at crop growth and harvest stages promoting pure crop stand.

These findings clearly illustrate that current breeding programme aimed towards the development of pole type varieties of dolichos suitable for round the year cultivation could successfully integrate photo-insensitive trait into the

Table 3. Mean evaluation scores for pod sensory characteristics and yield of selected breeding lines

Sl. No.	Advanced breeding lines	Pod length	Pod colour	Taste	Texture	Cooking quality	Over all Acceptance	Pod yield	Total
		10 points	10 points	10 points	10 points	20 points	30 points	10 points	100 points
1.	IIHR 15-15	9.5	9.3	9.5	9.4	9.2	19.4	29.3	95.6
2.	IIHR 15-5	9.2	9.0	10.0	9.2	9.5	18.8	27.5	93.2
3.	IIHR 15-23	9.4	9.8	9.6	9.2	9.6	19.0	28.0	94.6
4.	IIHR 15-21	9.4	9.0	9.0	9.3	9.3	18.8	27.5	92.3
5.	IIHR 15-8	9.1	9.3	10.0	9.0	9.3	17.6	27.2	91.5
6.	IIHR 15-7	9.0	9.8	9.8	9.0	9.4	18.3	28.8	94.1

Scores obtained are mean values based on sample evaluation from 30 individual respondents.

selected lines as obvious from the results obtained. Further, the average yields realized from the advanced breeding lines during both kharif and rabi were exceedingly higher than all the popular checks used in the present study that make them highly amenable to utilize directly as varieties or as potential parents for future breeding programmes. Apart from this, all the selected breeding lines differed widely for sensory characteristics that gratify the needs of assorted consumer sections across the country. Hence, the selected lines would customarily appease the choice of divergent consumer sections and invariably encourage farmers to cultivate vegetable dolichos throughout the year.

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