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VRPLK-2: A superior genotype of spinach beet for round the year cultivation

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Abstract

The aim of present study on spinach beet was to evaluate the performance of best performing genotypes during round the year monthly sowing for two consecutive years in the climes of northern Indian plains at ICAR-Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh. The marketable biomass yield for VRPLK-2 was realized 136-887 q/ha during round the year sowing which is 56-147% higher than check variety All Green because of faster plant growth, 16-33 days delayed-bolting habit and 1-2 more number of cutting(s). Overall, the biomass yield of spinach beet was harvested maximum during August to November sowing (Autumn & Winter season crop) followed by December to February sowing (Spring season crop) and minimum during March to July sowing (Summer & Rainy season crop). Higher biomass yield potential, delayed-bolting habit, faster plant growth, more number of cutting, longer cropping period and wider adaptability to different growing conditions & seasons for genotype VRPLK-2 make it a unique genotype whose genetic potential could be utilized in breeding programmes to widen the genetic variability towards delayed bolting habit and to increase the genotypic adaptability in varied climates in spinach beet.

Keywords: Spinach beet, Palak, *Beta vulgaris* L. ssp. *vulgaris*, Round the year, Biomass yield, Heat tolerant, Abiotic stress

Introduction

Spinach beet or palak [*Beta vulgaris* L. ssp. *vulgaris* var. *cicla* or *Beta vulgaris* L. ssp. *vulgaris* (Cicla Group)] is also known as beet leaf, desi palak or Indian spinach. The genus *Beta* (2n=2x=18) belongs to the subfamily Betoideae and family Amaranthaceae (formerly Chenopodiaceae); and the major and closely related cultivated crops of *Beta* genus are spinach beet, swiss chard, garden beet, fodder beet, sugar beet and ornamental beet (Singh et al. 2021). All the cultivated beets likely originated from a halophytic wild progenitor i.e. sea beet, *B. vulgaris* ssp. *maritima* (Biancardi et al. 2012). Spinach beet is one of the most common leafy vegetables of sub-tropics and tropics, and is grown & consumed widely in Indian subcontinent. The leaf beet group has a long history dating to the 2nd millennium BC (2000-1000 BC). The first cultivated forms were believed to have been domesticated in the Mediterranean, and were introduced to the Middle East, India, and finally China by 850 AD. These were used as medicinal plants in Ancient Greece and Medieval Europe. As descendants of coastal cliffs and stony beaches of northern Mediterranean regions and halophytic ancestor, spinach beet too tolerates salty soils and drought. Spinach beet prefers relatively cool temperatures between 15-20 °C & cultivated mainly during winter season, but also thrives in warmer temperatures. It is a long-day plant which is harvested when its rosette leaves are nearly fully expanded at its vegetative growth stage. As a long-day plant, the photoperiod has a great limitation on the round the year production of spinach beet.

The leafy vegetables, including spinach beet, are repeat-cycle crops, having growing period of about 50-90 days, and an important source of income for smallholding farmers. For extending the harvest period, the farmers often do staggered sowing or re-sow their field after harvest. Now-a-days, leafy vegetables are seen as an asset for the fight against "hidden hunger", the term used to describe deficiencies of micro-nutrients such as vitamin A and minerals like iron, zinc & iodine. Leafy vegetables are one of the best options because of easily accessibility, availability & affordability to get rid or minimize the severity of hidden hunger. Spinach beet is an important & nutritious leafy vegetable which provides nature's best nutrition supplement; packed with minerals like calcium, potassium, iron, phosphorus, zinc, copper & manganese; vitamins especially vitamin-A, vitamin-C

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& folate; antioxidants (Anonymous 2020); and fibre which are vital components of a healthy & balanced diet to human. The tender & soft leaves are usually cooked as saag, a culinary Asian specialty particularly in Indian subcontinent, and very much suitable for making concentrates, powder & fortification of food items. The palak growing Indian states are Uttar Pradesh, West Bengal, Punjab, Haryana, Delhi, Madhya Pradesh, Chhattisgarh, Rajasthan, Himachal Pradesh, Uttarakhand, Bihar, Jharkhand, Odisha, Maharashtra and Gujarat. However, it is less popular in the Southern states, especially Tamil Nadu and Kerala (Singh et al. 2021).

Production of spinach beet is constrained by various abiotic factors during off-season such as high temperature, long-day and rainfall, especially in North Indian plains. The extreme weather conditions not only lead to limited plant growth & yield loss, but also escalate the prices of spinach beet in the market by 3-8 times than normal season. Since both hot-weather and long-days (photoperiod) trigger spinach beet to bolt (initiation and rapid lengthening and of the floral stem or seed stalk) quickly, the secret to success with this crop is to start sowing seeds during suitable growing season and selection of heat/humid and bolting tolerant varieties for cultivation during non-conventional growing seasons. During the process of bolting, the shoot apical meristem differentiates into the inflorescence meristem and eventually the floral meristem, which then develops into various floral organs. Chen et al. (2019) confirms that photoperiod, temperature, endogenous hormones and genotypic ability regulate bolting and flowering either independently or together. Bolting, a major problem for production systems of leafy vegetables, including spinach beet, can be prevented/delayed by manipulating the photoperiod & temperature, exogenous application of growth regulators, and genetic architecture. Once bolting initiated in spinach beet grown for the tender leaves, it loses its economic value, becoming bitter and hard. The usages of bolting tolerant genotypes (delayed bolting habit) could be a good choice for the year-round production of spinach beet.

Season is a division of the year marked by changes in weather, ecology, and the amount of day-light. The growing season is that portion of the year in which local conditions (i.e. temperature, day-light, rainfall, etc.) permit normal plant growth. Each crop has a specific growing season that depends on its genetic adaptation and growing conditions. Production of spinach beet during off-season is a profitable venture as it fetches premium price of produce i.e. about 3-6 times higher than normal price within short period. The right choice of cultivars is of paramount importance for successful cultivation of palak during off-season. The varieties having the traits like delayed bolting habit, heat/humid tolerant, quick regeneration ability and longer stay-green are the most suitable for growing during summer/rainy seasons. Selection of breeding materials for stress and bolting tolerance are very imperative horticultural traits for breeding which ultimately facilitate the farmers to grow spinach beet successfully and get premium price of their produce during off season. Experiencing the lack of suitable cultivars for off-season cultivation, the present study was undertaken to evaluate the performance of best genotype in monthly sowing for two consecutive years in the climes of northern Indian plains at ICAR-Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh.

Materials and Methods

The field experiments were carried out at the Research Farm, ICAR-IIVR, Varanasi, UP during two consecutive years i.e. 2018-19 and 2019-2020. The research farm is located at 25°10'55'' N latitude and 82°52'36'' E longitude with an altitude of 85 m above the mean sea level, and receives an annual rainfall of 1050-1100 mm. Varanasi's three fourths of the total annual rainfall are received during July-August months. The soil of the Farm was of silt-loam in texture, having pH 7.3 and electrical conductivity of 0.28 dSm^{-1}. Mean monthly meteorological parameters such as minimum and maximum temperature (Tmin and Tmax), minimum and maximum relative humidity (RHmin and RHmax) and sunshine hour, and total rainfall for the cropping period are summarized (Table 1) for better understanding and interpretation of data of seasons and genotype. The plot size was kept as 6.0×2.4 m, and the multigerm seeds, botanically fruit, were sown in double rows of 7-8 cm apart and 25-28 cm wide ridge with the spacing of 60 cm between each pair of ridges at a distance of 1.5-2.0 cm. The best performing genotype 'VRPLK-2' (bred at ICAR-IIVR, Jakhini, Varanasi, UP; IC0632944; named as Kashi Baramasi) was compared with a national check variety 'All Green' (released by ICAR-IARI, Pusa, New Delhi) by sowing seeds in the mid of every months from January to December for two consecutive years. The fertilizers such as $N:P_2O_5:K_2O$ @ 80:50:40 kg/ha were supplied by urea, single super phosphate (SSP) and muriate of potash (MOP), respectively. The half dose of N, and full dose of P_2O_5 and K_2O was applied as basal at final plot dressing; and rest half N was top-dressed after first cutting. During both year of experimentation, soil preparation, sowing and other agronomic practices were carried out unvaryingly for better morphological expression and leaf development. The pooled data were analysed statistically using

Table 1: Mean monthly meteorological parameters at ICAR-Indian Institute of Vegetable Research, Varanasi, UP (2018-19 and 2019-20)

Month	Temperature (°C)			Sunshine (hr)	Relative humidity (%)			Total rainfall (mm)
	Max	Min	Mean		Max	Min	Mean	
April	38.9	22.1	30.5	8.8	69	27	48	5.2
May	42.2	27.2	34.7	9.3	63	27	45	0.0
June	41.9	29.7	35.8	8.0	66	38	52	39.0
July	35.5	27.2	31.4	5.8	83	61	72	263.2
August	32.8	26.3	29.5	4.8	90	74	82	466.4
September	33.5	26.0	29.8	7.0	85	67	76	0.0
October	33.6	21.1	27.4	8.3	79	43	61	0.0
November	29.3	15.1	22.2	7.4	88	36	62	0.0
December	23.6	8.9	16.3	5.5	90	38	64	0.0
January	22.5	9.5	16.0	5.2	90	48	69	0.0
February	25.8	12.0	18.9	6.8	87	49	68	9.6
March	31.2	15.5	23.3	8.1	83	39	61	3.7

Microsoft Excel programme. Mean values of both years for the parameters measured for the tested genotypes were compared with standard error bars with $p<0.05$ to identify homogeneity of data among sowing months and varieties.

Results and Discussion

Spinach beet is a short duration and fast growing leafy vegetable, and ready for first harvest or cut in 32-38 days after sowing in the year round sowing for every month. Further, higher regeneration ability of crop favours multiple harvests or cuttings. To get quality and economical and marketable biomass produce, last harvesting was done at the stage when crops attended more than 65% bolting. The response of VRPLK-2 and All Green for economic traits such as marketable biomass yield, number of cutting, cropping period and biomass production per cutting in round the year sowing for 12 times i.e. mid of every month covering different growing seasons (summer, rainy, autumn, winter and spring seasons) for two consecutive years 2018-2020 are presented in Figures 1 to 4 and Table 2.

Marketable biomass yield for VRPLK-2 was maximum i.e. 887 q/ha in mid-September sowing followed by 862 q/ha in mid-August, 727 q/ha in mid-October, 570 q/ha in mid-November, and minimum i.e. 136 q/ha in mid-February, 158 q/ha in mid-January, 179 q/ha in mid-May and 182 q/ha in mid-March sowing which is about 43.0%, 62.6%, 42.6% & 49.0% and 148.8%, 81.8%, 65.5% & 112.3% higher than check variety All Green, respectively (Figure 1 and Table 2). Overall, the respective biomass yield for VRPLK-2 and All Green was realized maximum i.e. 762 & 510 q/ha (49.4% higher) during August to November sowing (Autumn & Winter season crop) followed by 211 & 126 q/ha (91.2% higher) during December to February sowing (Spring season crop), 192 & 108 q/ha (78.3% higher) during March to July sowing (Summer & Rainy season crop), and 386 & 247 q/ha (56.5% higher) across the year round sowing i.e. from January to December.

Table 2: Agronomical and yield traits of 'VRPLK-2' and check 'All Green' during different season (Mean of 2018-19 and 2019-20)

Sowing month	Variety	Marketable biomass yield (q/ha)	Increase in yield (%)	Number of cutting	Total cropping period (days)	Biomass production per cutting (q/ha)
March to July sowing (Summer/ rainy season crop)	All Green	108 (86-123)	-	1.9 (1.5-2.0)	53 (47-61)	57 (54-62)
	VRPLK-2	192 (179-209)	78.3 (65.5-112.3)	2.9 (2.5-3.0)	70 (65-76)	66 (60-73)
August to November sowing (Autumn/ winter season crop)	All Green	510 (383-620)	-	5.3 (3.5-6.5)	101 (68-132)	97 (81-109)
	VRPLK-2	762 (570-887)	49.4 (42.6-62.9)	6.3 (4.5-7.5)	123 (82-165)	122 (115-127)
December to February sowing (Spring season crop)	All Green	126 (55-236)	-	1.3 (1-2)	41 (33-53)	94 (55-118)
	VRPLK-2	211 (136-338)	91.2 (43.1-148.8)	2.3 (2-3)	54 (46-63)	90 (68-113)
Mean of 12 months sowing	All Green	247		2.9	66	78
	VRPLK-2	386	56.5	3.9	83	90

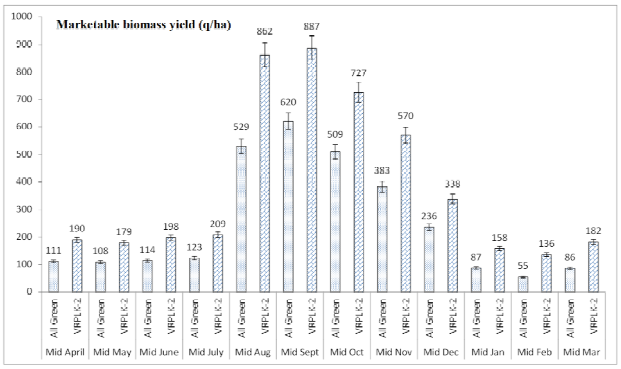

Figure 1: Marketable biomass yield (q/ha) of 'VRPLK-2' and check 'All Green' (Round the year sowing); (Mean of 2018-19 and 2019-20)

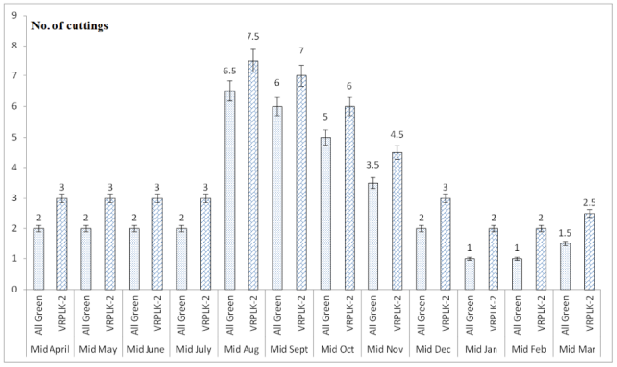

Figure 2: Number of cuttings in 'VRPLK-2' and check 'All Green' (Round the year sowing); (Mean of 2018-19 and 2019-20)

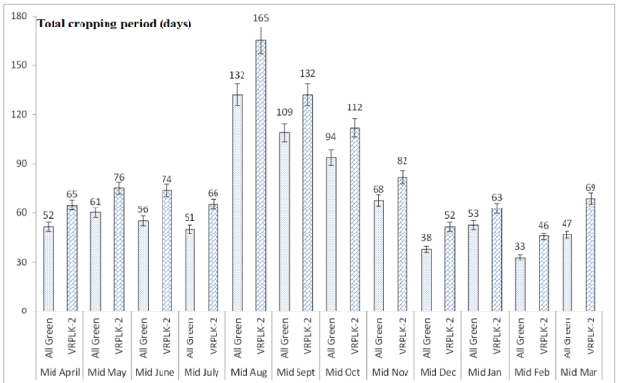

Figure 3: Total cropping period (days) of 'VRPLK-2' and check 'All Green' (Round the year sowing); (Mean of 2018-19 and 2019-20)

Prevalence of higher temperature and/or long photoperiod during off-season (except autumn/winter crop) accelerate(s) the process of transition from vegetative to reproductive phase i.e. bolting, and thereby affects leaf quality and biomass yield negatively. Phenological stage of plants such as bolting is not desirable when spinach beet is cultivated for leaf biomass production and it is predominantly suppressed during

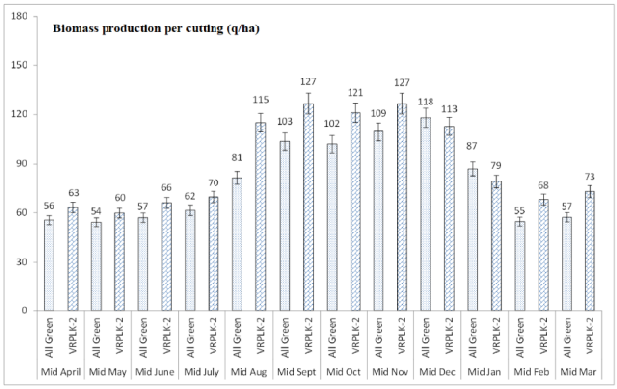

Figure 4: Biomass production per cutting (q/ha) of 'VRPLK-2' and check 'All Green' (Round the year sowing); (Mean of 2018-19 and 2019-20)

breeding programmes, though it is important in seed production.

Generally, VRPLK-2 realized 1-2 more number of cutting(s) than check variety All Green during year round sowing in different seasons (Figure 2 & Table 2). VRPLK-2 of spinach beet crop was harvested maximum for 7.5-time followed by 7-time, 6-time & 4.5-time, respectively when the crop was sown in mid-August, mid-September, mid-October and mid-November. For VRPLK-2, the number of cuttings was minimum i.e. 2-time for mid-January and mid-February sown crop, and 2.5-3.0-time for mid-December & mid-April to mid-July sown crop. The shorter life cycle of spinach beet during spring season and off-season favours less number of cuttings because of occurrence of early bolting. The present study also confirms that number of cuttings/ pickings is directly correlated with biomass yield potential of spinach beet. Spinach crop grown under the long-day conditions of spring/summer have a greater tendency to bolt and flower (Singhal and Kulkarni 1998).

Total cropping period (day) was counted from date of sowing to last harvesting (cutting) i.e. >65% bolting stage. The cropping period for marketable yield of spinach beet sown round the year (January to December) ranged from 46-165 days (x=83 days) for VRPLK-2 and 33-132 days (x=66 days) for check variety All Green (Figure 3, Table 2). The respective cropping period for VRPLK-2 and All Green was higher 123 days (August to November sowing), 70 days (March to July sowing) & 54 days (December to February sowing), and 101 days (August to November sowing), 53 days (March to July sowing) & 41 days (December to February sowing). About 10-33 days higher cropping period of VRPLK-2 over All Green was attributed because of genetic potential of VRPLK-2 for delayed bolting habit which ultimately added 1-2 more cuttings

and thereby increasing total biomass yield. It is very obvious that longer the cropping period higher the biomass yield of spinach beet.

Biomass production per cutting or harvesting was calculated to observe the plant growth and biomass production ability. Biomass production per cutting (q/ha) sown round the year ranged from 60-127 q/ha (x=90 q/ha) for VRPLK-2 and 54-118 q/ha (x=78 q/ha) for All Green (Table 2). Further, biomass production per cutting was significantly at par for both genotypes (VRPLK-2 & All Green) when crop was sown during mid of April, May, July, December and January (Figure 4). During round the year sowing, the respective biomass production per cutting for VRPLK-2 and All Green was higher 122 & 97 q/ha in August to November sowing followed by 90 & 94 q/ha in December to February sowing, and 66 & 57 q/ha in March to July sowing indicating faster plant growth of VRPLK-2 sown during autumn and winter seasons.

In conclusion, VRPLK-2 is a superior genotype of spinach having biomass yield potential of 136-887 q/ha during round the year sowing surpassing about 56-147%, faster plant growth, 16-33 days delayed-bolting habit and 1-2 more number of cutting(s) over check variety All Green. Overall, the biomass yield of spinach beet was harvested maximum during August to November sowing followed by December to February sowing and minimum during March to July sowing. Higher biomass yield potential, delayed-bolting habit, faster plant growth, more number of cutting, longer cropping period and wider adaptability to different growing conditions & seasons for genotype VRPLK-2 make it a unique genotype whose genetic potential could be utilized in breeding programmes to widen the genetic variability towards delayed bolting habit and to increase the genotypic adaptability in varied climates in spinach beet.

सारांश

वर्तमान अध्ययन का उद्देश्य पालक की पूरे वर्ष खेती करने के लिए सबसे उत्तम प्रभेदों की क्षमता निष्पादन का मूल्यांकन करना है। इसके लिए उत्तर भारत के मैदानी क्षेत्रों में वर्ष भर प्रत्येक महीने लगातार बुआई भा.कृ.अनु.प.–भारतीय सब्जी अनुसंधान संस्थान, वाराणसी (उ.प्र.) में की गयी। प्रभेद वी.आर.पी.एल.के.–2 में सबसे ज्यादा बाजार योग्य उपज 136–887 कुन्तल प्रति हेक्टेयर पूरे वर्ष बुआई करने से प्राप्त हुई जो नियंत्रक प्रभेद आलग्रीन से 56–147 प्रतिशत अधिक था क्योंकि इसमें सबसे तेज पौध विकास, 16–33 दिनों तक देर से पुष्प दण्ड विकसित करने की प्रवृत्ति एवं 1–2 बार ज्यादा कटाई करने से हुआ। सम्पूर्ण पालक की उपज जैव भार सबसे अधिक अगस्त–नवम्बर माह की बुआई (शरद ऋतु तथा शीत काल) से प्राप्त हुई तथा इसके बाद फरवरी माह की बुआई (वसंत कालीन फसल) एवं सबसे कम उपज मार्च से जुलाई माह की बुआई (ग्रीष्म व वर्षाकालीन फसल) से प्राप्त हुयी। सबसे अधिक उपज जैव भार, देर से पुष्प दण्ड विकास की प्रवृत्ति, तेज पौध विकास, ज्यादा संख्या में कटाई, लम्बे समय तक फसल उगाने की प्रवृत्ति तथा विभिन्न खेत की दशा में उगाने का अनुकूलन व मौसम में वी.आर.पी.एल.के.–2 प्रभेद की समावेश विशिष्टता है, तथा इसके उपयोग को प्रजनन के माध्यम से अनुवांशिक प्रसार को विविधता दी जा सकती है।

References

Anonymous (2020) https://nutritiondata.self.com/facts/vegetables-and-vegetable-products/2352/2.

Biancardi E, Panella LW and Lewellen RT (2012) *Beta maritima*: the origin of beets. Springer, New York, pp 75-84.

Chen C, Huang W, Hou K and Wu W (2019) Bolting: An important process in plant development, two types in plants. J Plant Biol 62:161-169.

Oyen LPA (2004) *Beta vulgaris* L. PROTA- Plant resources of tropical Africa. Wageningen, Netherlands,https://www.prota4u.org/database/protav8.asp?h=M4&t=Beta, vulgaris&p=Beta+vulgaris.

Singh BK, Karmakar P, Pandita ML, Maity TK and Lal S (2021) Spinach beet and spinach. In: Vegetable Crops Vol-3 (Som MG, Bose TK, Chattopadhyay A, Maity TK and Kabir J Eds). Daya Publishing House, Astral International Pvt. Ltd., Darya Ganj, New Delhi, pp 871-920 (ISBN 9789390435227).

Singhal RS and Kulkarni PR (1998) Leafy vegetables. In: Handbook of vegetable science and technology: Production, composition, storage, and processing (Salunkhe and Kadam eds.). Marcel Dekker, New York, pp 533–588.