Effect of different sowing windows on dry matter accumulation of pigeonpea genotypes

Abstract

A field experiment was conducted to study the "Effect of different sowing windows on dry matter accumulation of pigeonpea genotypes" at Regional Agricultural Research Station, Vijayapura, during *Kharif* 2021. The experiment was laid out in a split-plot design assigning four sowing windows to main plots *viz*., first fortnight of June (23-24th SMW), second fortnight of June (25-26th SMW), first fortnight of July (27-28th SMW) and second fortnight of July (29-30th SMW), whereas genotypes to subplot *viz.*,TS-3R, GRG-152 and GRG-811 and replicated thrice. The results revealed that sowing in first fortnight of June accumulated more dry matter in leaves (18.47 g plant^{-1}), stem (131.22 g plant^{-1}) and reproductive parts (68.16 g plant^{-1}). Among the genotype GRG-152 accumulated higher dry matter in leaves (17.34 g plant^{-1}) and stem (123.01 g plant^{-1}). However, dry matter accumulation in reproductive parts is higher in TS-3R (63.68 g plant^{-1}). Similarly TDMP was higher in first fortnight of June sowing (217.85 g plant^{-1}) than delayed sowing in second fortnight of July. TS-3R accumulated higher TDMP in the beginning growth stage when compared to GRG-152 and GRG-811. However, TDMP was higher in GRG-152 at later stage. This study revealed that pigeonpea sown in first fortnight of June recorded higher dry matter production and it's partitioning in leaf, stem and reproductive parts and among the genotype TS-3R recorded significantly higher dry matter in pods due to more photosynthetic activity of the genotype which results in higher yield of the crop.

Key words: Sowing windows, Total dry matter production (TDMP), Standard meteorological week (SMW)

Introduction

Pigeonpea (*Cajanus cajan* L.) is commonly known as red gram / arhar / tur, and its origin is in South Africa. It is an important grain legume that belongs to the Fabaceae (Leguminaceae) family and widely cultivated pulse crop in India. It is a short-lived perennial forage shrub with strong deep tap root system and can be adapted to a wide range of soil types from gravel-like soil to heavy clays, provided there is no standing water on the soil surface Saxsena et al. [22]; Hidosa et al. [10]. It is a common food grain crop and offers nutritional security due to its richness in protein (21%) with essential amino acids such as methionine, lysine and tryptophan along with mineral supplementation *viz.*, iron and iodine. In addition to its nutritional value, it also has a unique property of maintaining and restoring soil fertility through biological nitrogen fixation and improvement of physical properties of the soil by virtue of its deep root system. The growth and development of pigeonpea vary from location to location due to variability in agro-climatic and soil-water related parameters. Even in the same location, variability in growth takes place due to different growing environments created by sowing dates, cultivars and other cultural and management practices. Ahlawat and Rana [2]. Pigeonpea is grown throughout the tropical and sub-tropical regions of the world and warmer temperature regions between 30^0 N and 35^0 S latitudes. However, a major area under pigeonpea in India is lying between 14^0 and 28^0 N latitudes. India has the distinction of being the world's largest producer and consumer of pulses, including pigeonpea. It is one of the protein rich legume crops of semi arid and sub tropic region. Due attention for this crop is required in view of the large scale shortage of pulses to meet the domestic requirement. The area under pigeonpea cultivation in India is 4.90 m ha and production of 4.22 m tonnes with a productivity of 861 kg ha^{-1} anonymous [3]. Karnataka ranks first in terms of area (35.08%), followed by Maharashtra (27.24%). Karnataka is one of the pigeonpea growing state having an area of 1.72 m ha with a production of 1.14 m tonnes and productivity of 666 kg ha^{-1} anonymous [3]. Optimum sowing windows helps in utilizing the available moisture and nutrients from the soil more effectively and leads to better dry matter production and accumulation which reflects in yield of crop. The dry matter production and its accumulation are the best measure and index of the total performance and response of a crop to weather conditions Mall et al. [13]. The yield of a crop does not largely depend on the dry matter production alone but also in its distribution to reproductive parts; as major part of the dry matter is translocated to sink from source. Acevedo et al. [1]. In particular, photosynthetic active radiation (PAR) is the major factor regulating photosynthesis and other physiological processes in plants. Hence, the dry matter production and yield depends on it to a greater extent. Lemaire et al. [12]. Sowing time also plays an important role in dry matter accumulation by the crop. Early sown crops may accumulate more dry matter, whereas late sown crops may reduce biomass accumulation and consequently a reduction in yield. Many researchers found that the delayed sowings beyond the optimum period result in low grain yields of pigeonpea. Behera et al. [5]; Rajani et al. [20]; Niveditha et al. [15]. Selection of suitable genotypes that perform a stable photosynthesis under different growing environment will be a greater advantage to get high and stable productivity under the natural environment. Therefore, the present field investigation was carried out to identify the optimum sowing windows and suitable genotypes under different weather scenarios and evaluate their subsequent effect on pigeonpea productivity. It is, therefore, important to study how pigeonpea genotypes perform in changing weather scenarios through sowing windows, especially in the Northern Dry Zone of Karnataka. Keeping this in view, the experiment entitled "Crop-weather relationship of pigeonpea under changing weather scenarios" was executed at Regional Agricultural Research Station, Vijayapura, during *kharif* 2021.

Material and methods

The experiment was conducted at the Regional Agricultural Research Station (RARS), Vijayapura and it is located at latitude of 16^{0}46' 15.16" North, the longitude of 75^{0}44' 53.78' 'East and an altitude of 593.8 meters above the mean sea level. The experimental site is in the jurisdiction of the Northern Dry Zone of Karnataka (Zone 3). The soil of the experimental site is medium deep black and the texture of the soil is a clayey loam belonging to the order *Vertisols*. The soil samples were taken randomly from experimental plot to a depth of 0-15 cm before layout and composite soil sample was prepared and analyzed for physical as well as chemical properties of soil.

Crop growth is mainly dependent on environmental factors. The fluctuations in weather variables greatly influence crop growth, development and yielding potential. The adequate availability of soil moisture over the growing period of a crop is essential for fortunate crop production in rainfed areas. Meteorlogical data for the location was obtained from the observatory of Regional Agricultural Research Station (RARS), Vijayapura (Karnataka). The average monthly meteorological data for the experimental year (2021) and average of past 40 years (1981-2020) are presented in Table 1.

Treatments included four main plots with sowing windows (D) *viz*., D_1: first fortnight of June (23-24th SMW), D_2: second fortnight of June (25-26th SMW), D_3: first fortnight of July (27-28th SMW), D_4: second fortnight of July (29-30th SMW) and three subplots with three genotypes (G) *viz*., G_1: TS-3R, G_2: GRG-152 and G_3: GRG-811. The field was ploughed once after the harvest of the previous crop and harrowed to obtain fine seedbed. During sowing, the land was prepared to a fine seedbed and the plots were laid out as per the experiment's layout and Staggered sowing was done as per the treatments at different sowing windows by hand dibbling with 1-2 seeds per hill. The crop was sown by providing recommended spacing of 120 cm inter-row and 20 cm intra-row as per the treatments. The crop was considered to mature when 95% of pods have obtained their mature colour after that harvesting was done. In the present study, the observations taken at different phenological stages of pigeonpea, namely S_2: initiation of primary branch, S_3: secondary branch, S_5: 50% flowering and S_7: physiological maturity.

The data collected from the experiment at different phenological stages were subjected to statistical analysis as per split-plot design described by Gomez and Gomez [9]. The influence of four sowing windows as main plot and three genotypes as subplot in the split plot design which was replicated thrice which is subjected for test of two way ANOVA. The means of treatment combination were compared by the LSD (Least significant difference) test upon significant results of F test at $p<0.05$. Summary tables for treatment effect have been prepared and furnished with standard error of means (S.Em±) and critical difference (C.D.) at 5% level of probability ($p=0.05$) has also been given where the treatment differences were significant.

Result and discussion

Sowing windows significantly influenced the dry matter accumulation in leaves at all the phenological stages (Fig. 1). In the beginning growth stages, dry matter accumulation in the leaves was in increasing trend at primary branch, secondary branch and 50% flowering, on the contrary, at physiological maturity, it was decreasing trend. The mean leaf dry weight was higher under the first fortnight of June sowing (5.83, 11.64, 35.41 and 18.47 g plant^{-1}, respectively) at all the stages. However, significantly lower values (2.47, 7.37, 21.87 and 13.42 g plant^{-1}, respectively) were recorded under the second fortnight of July sowing at all the stages. The pigeonpea sown in first fortnight of June accumulated significantly higher dry matter in leaves, this increase in dry matter accumulation in the beginning growth stage may be due higher amount of rainfall, bright sunshine hours which leads to increase in plant height, number of branches, number of leaf and more photosynthetic activity intern which result in more dry matter accumulation in leaves. Similar results of variation in dry matter production among the sowing windows were reported by Chauhan et al. [6]; Kumar et al. [11] in pigeonpea. Similarly, Dhanoji and Patil [7] observed a significant decrease in dry matte accumulation and seed yield with late-sown pigeonpea. The effect of genotypes on dry matter accumulation in leaves also showed significant (Fig. 2). TS-3R produced significantly higher leaf dry weight at initiation of primary branch stage (4.36 g plant^{-1}), which was on par with GRG-152 (4.07 g plant^{-1}) and in comparison, GRG-811 recorded lower leaf dry weight (3.76 g plant^{-1}). But at later stages, the trend was reversed where, GRG-152 recorded higher leaf dry weight (9.95, 30.36 and 17.34 g plant^{-1}, respectively) at secondary branch stage, 50% flowering and physiological maturity. While, lower leaf dry weight (8.86, 27.19 and 14.99 g plant^{-1}, respectively) was recorded by the genotype TS-3R at secondary branch stage, 50% flowering and physiological maturity. The increase in leaf dry matter in the TS-3R is due to faster growth rate in the early stages when compared to GRG-152 and GRG-811 but later the other two genotypes overtook the TS-3R. As GRG-152 and GRG-811 was long duration genotype compared to TS-3R which produce more leaf dry matter due to higher accumulation of photosynthates and its partitioning in the leaf which resulted in more dry matter of leaves at later stage. Early sowing of determinate cultivars could maximize both vegetative and reproductive growth, capture more light and produce more seed yields. Patel et al. [16].

A significant variation in dry matter accumulation in the stem was observed due to various sowing windows at all the phenological stages (Fig. 1). The stem dry weight was higher in first fortnight of June sowing at all the stages (7.73, 37.85, 61.15 and 131.22 g plant^{-1}, respectively). However, significantly lower dry matter of stem was observed under second fortnight of July sowing at all the growth stages (76, 28.42, 42.39 and 113.53 g plant^{-1}, respectively). The increase in stem dry matter during early sowing is may be due to longer vegetative growth phase as sowing delays the duration for completion of life cycle reduces and hence dry matter accumulation also decreases. Similar results also reported by Balakrishnan et al [4]. The genotypes marked significant variation in the dry weight of the stem at all phenological stages (Fig. 2). Among the genotypes, TS-3R was recorded higher stem dry matter (6.46 g plant^{-1}) at initiation of primary branch followed by GRG-152 (6.14g plant^{-1}) over other genotype GRG-811 (6.02). But, GRG-152 has observed significantly higher stem dry weight (34.56, 52.96 and 123.01 g plant^{-1}, respectively) at later stages, which was statistically on par with GRG-811 (34.03 and 52.47 g plant^{-1}, respectively) at secondary branch and 50% flowering. At the same time, TS-3R recorded minimum stem dry weight at all the stages (32.35, 49.09 and 120.80 g plant^{-1}, respectively). The increase in dry matter accumulation in TS-3R at primary branch stage may be due to vigorous growth of the plant during early crop growth stage but later GRG-152 and GRG-811 recorded higher dry matter as longer vegetative duration of the crop which resulted in increasing stem dry matter.

The mean dry weight of reproductive parts (g plant^{-1}) recorded at 50% flowering and physiological maturity stages is presented in (Fig. 1). Sowing windows varied significantly for the dry weight of reproductive parts at 50% flowering and physiological maturity. The dry matter accumulation in reproductive parts also depends on the photosynthetic ability of plant at various growth stages. The dry weight of reproductive parts was higher (9.39 and 68.16 g plant^{-1}, respectively) in first fortnight of June sowing. However, significantly lower dry weight of reproductive parts (4.74 and 56.97 g plant^{-1}, respectively) recorded under second fortnight of July sowing at both stages. The dry matter accumulation in reproductive parts also depends on the photosynthetic ability of plant at various growth stage. The variation in the dry matter accumulation in the reproductive parts it may be due to the availability of sufficient time and favourable growing environment for the vegetative and reproductive growth under early sowing of the crop. The dry weight of reproductive parts varied significantly among the genotypes (Fig. 2). Where, TS-3R obtained significantly higher dry weight of reproductive parts (7.22 and 63.68 g plant^{-1}, respectively) at 50% flowering and physiological maturity over other genotype GRG-811 (6.40 and 61.72 g plant^{-1}, respectively) at both the stages. The increase in dry matter accumulation in reproductive part it may be due to inherent capacity of the genotype.

The total dry matter production (TDMP) recorded at the initiation of primary branch, secondary branch , 50% flowering and physiological maturity stages is presented in Table 2.

Sowing windows significantly influenced TDMP at all phenological stages. The significantly higher TDMP was observed in first fortnight of June sowing at all stages (13.57, 49.49, 105.95 and 217.85 g plant^{-1}, respectively).With the delay in sowing, dry matter production decreased as a result lower TDMP (7.23, 35.80, 68.99 and 183.92 g plant^{-1}, respectively) was produced by sowing in second fortnight of July at all the stages. The higher dry matter production plant^{-1} in first fortnight of June sowing may be due to significantly higher leaf area, number of branches leading to higher dry matter accumulation in leaves, stem and reproductive parts. The early sown crop remains in the field for a longer period and these crops are grown vigorously due to maximum utilization of solar radiation to produce photosynthates. Farz et al. [8]; Miah et al. [14]; Samant et al. [21] also recorded higher dry matter production in early sown crop of Mungbean. Genotype TS-3R at the initiation of primary branch (10.83 g plant^{-1}) produced higher dry matter than the other two genotypes, GRG-152 (10.22 g plant^{-1}) and GRG-811 (9.78 g plant^{-1}). However, at a later stage (initiation of secondary branch), dry matter production increased in GRG-152 (44.51 g plant^{-1}) and GRG-811 (43.76 g plant^{-1}) compared to TS-3R (41.20 g plant^{-1}). Likewise, at the physiological maturity stage TDMP was highest in GRG-152 and GRG-811 (203.57 and 201.13 g plant^{-1}) and lower in TS-3R (199.89 g plant^{-1}). This variation among the genotypes may be due to the early growth of TS-3R in the beginning stages than the other genotypes. Still, later stages GRG-152 and GRG-811 overtook TS-3R interms of their vegetative growth. Ramakrishna et al. [18]; Reddy [19] opined that a plant’s ability to produce dry matter depends on the size and length of the photosynthetic area. The genetic potentiality of the cultivar to produce and translocate higher assimilates in turn converts into total dry matter. However, TDMP alone does not wholly reflect the efficiency of genotypes but its accumulation in different parts particularly in reproductive parts of the plant is of significance in other words the source-sink relationship is important which is indicated by harvest index. When partitioning of TDM in different parts is examined, it was apparent that TS-3R accumulated a higher proportion of dry matter in pods throughout the reproductive phase than the other two genotypes. That apart, GRG-152 and GRG-811 accumulated higher stem and leaf dry matter. Such variations among the genotypes might be due to the genetic constitution of different genotypes, which provides the inherent capacity to perform in different ways. This result is in support of Patil et al. [17] in chickpea.

Conclusion

The study was conducted to evaluate the effect of sowing windows and pigeonpea genotypes on the dry matter production and partitioning in leaf, stem and reproductive parts. Pigeonpea sown in first fortnight of June produced more total dry matter production than delayed sowing in second fortnight of July. Among the genotype TS-3R accumulated a higher proportion of dry matter in pods throughout the reproductive phase than the other two genotypes. From the study we conclude that best time for pigeonpea sowing is first fortnight of June and among the genotypes TS-3R is best suited in the Northern Dry Zone of Karnataka.

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Table 1: Average monthly meteorological data for the experimental year (2021) and average of past 40 years (1981-2020) at Regional Agriculture Research Station, Vijayapura (Karnataka)

Months	**Rainfall (mm)**			**Number of rainy days**		**Maximum temperature (^{0}C)**		**Minimum temperature (^{0}C)**	
	Normal*	**2021**	**Deviation**	**Normal***	**2021**	**Normal***	**2021**	**Normal***	**2021**
January	4.1	10.2	148.8	0	1	29.9	30.9	16.1	15.9
February	2.7	0.0	-100.0	0	0	32.9	31.7	17.9	15.3
March	5.6	0.0	-100.0	0	0	36.3	36.5	21.5	19.9
April	20.9	35.9	71.8	2	4	38.6	37.6	21.1	22.5
May	39.6	65.7	65.9	3	7	39.1	36.1	24.2	23.4
June	85.4	60.2	-29.5	6	8	33.8	32.3	23.1	22.0
July	72.5	146.4	101.9	5	8	30.8	30.2	22.6	21.9
August	78.0	67.7	-13.2	5	6	30.5	30.6	21.7	21.4
September	151.6	161.7	6.7	8	12	31.4	29.6	21.8	21.3
October	97.3	33.2	-65.9	6	2	31.2	31.8	21.1	19.9
November	29.5	24.4	-17.3	2	2	29.8	29.6	17.5	19.0
December	7.2	27.4	280.6	1	2	29.1	28.8	16.1	15.0
Total	**728.3**	**632.8**	**-**	**38**	**52**	**-**	**-**	**-**	**-**

* Average of 40 years (1981-2020)

Table 2: Total dry matter production (TDMP) at different phenological stages of pigeonpea genotypes influenced by the growing environments

Treatments	**Total dry matter production (g plant^{-1})**			
	Initiation of Primary branch	**Initiation of Secondary branch**	**50% flowering**	**Physiological maturity**
Sowing windows				
First fortnight June	13.57	49.49	105.95	217.85
Second fortnight June	11.37	46.60	95.92	209.19
First fortnight July	8.92	40.74	78.60	195.15
Second fortnight July	7.23	35.80	68.99	183.92
S.Em±	0.35	1.57	2.43	5.29
C.D. ($p=0.05$)	1.22	5.42	8.40	18.31
Genotypes				
TS-3R	10.83	41.20	83.49	199.89
GRG-152	10.22	44.51	90.22	203.57
GRG-811	9.78	43.76	88.38	201.13
S.Em±	0.06	0.17	0.42	0.26
C.D. ($p=0.05$)	0.18	0.50	1.25	0.78
Sowing windows x Genotypes ($p=0.05$)	0.36	0.99	2.49	1.57

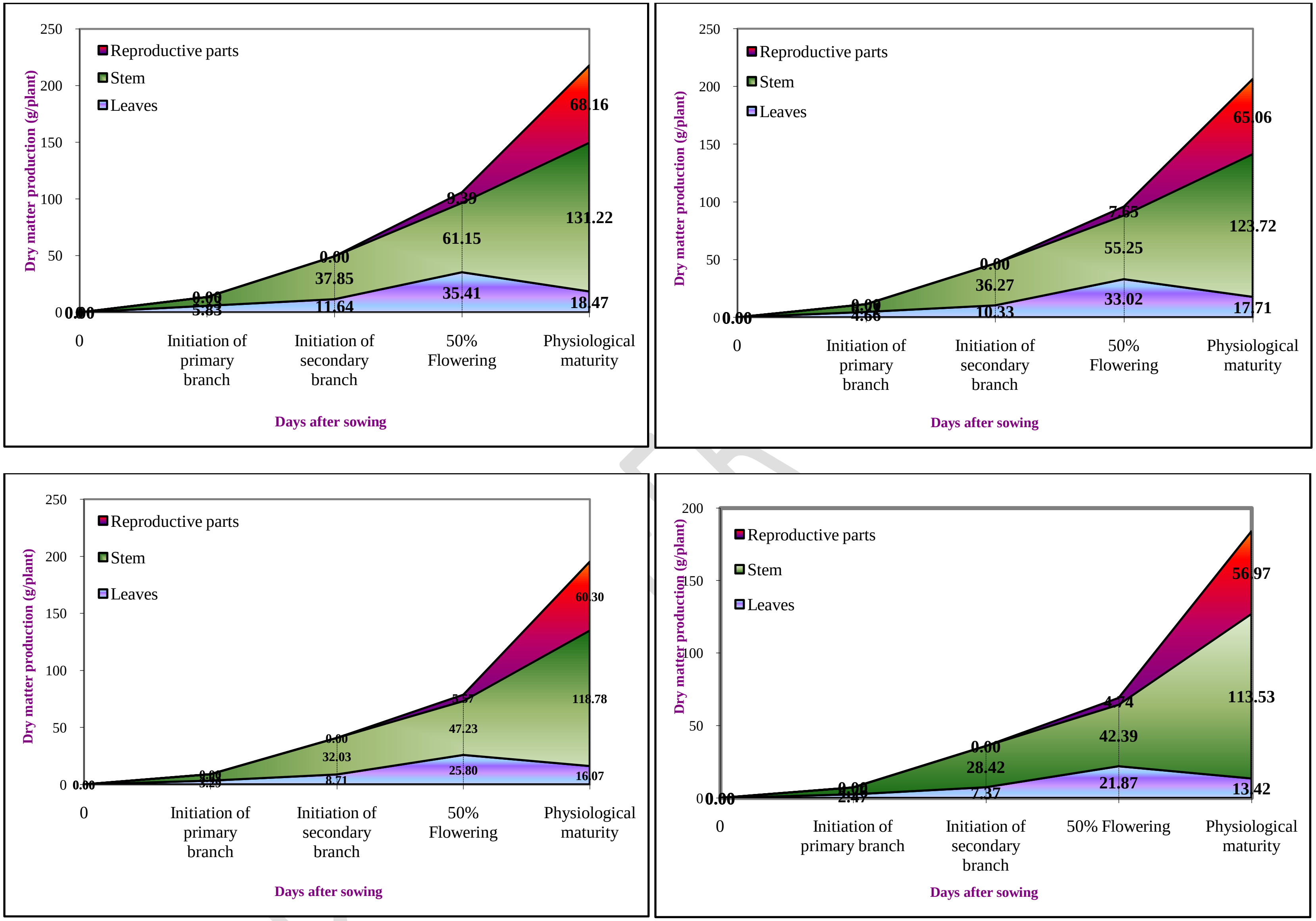

Fig. 1: Dry matter accumulation in different parts of pigeonpea genotypes as influenced by sowing windows

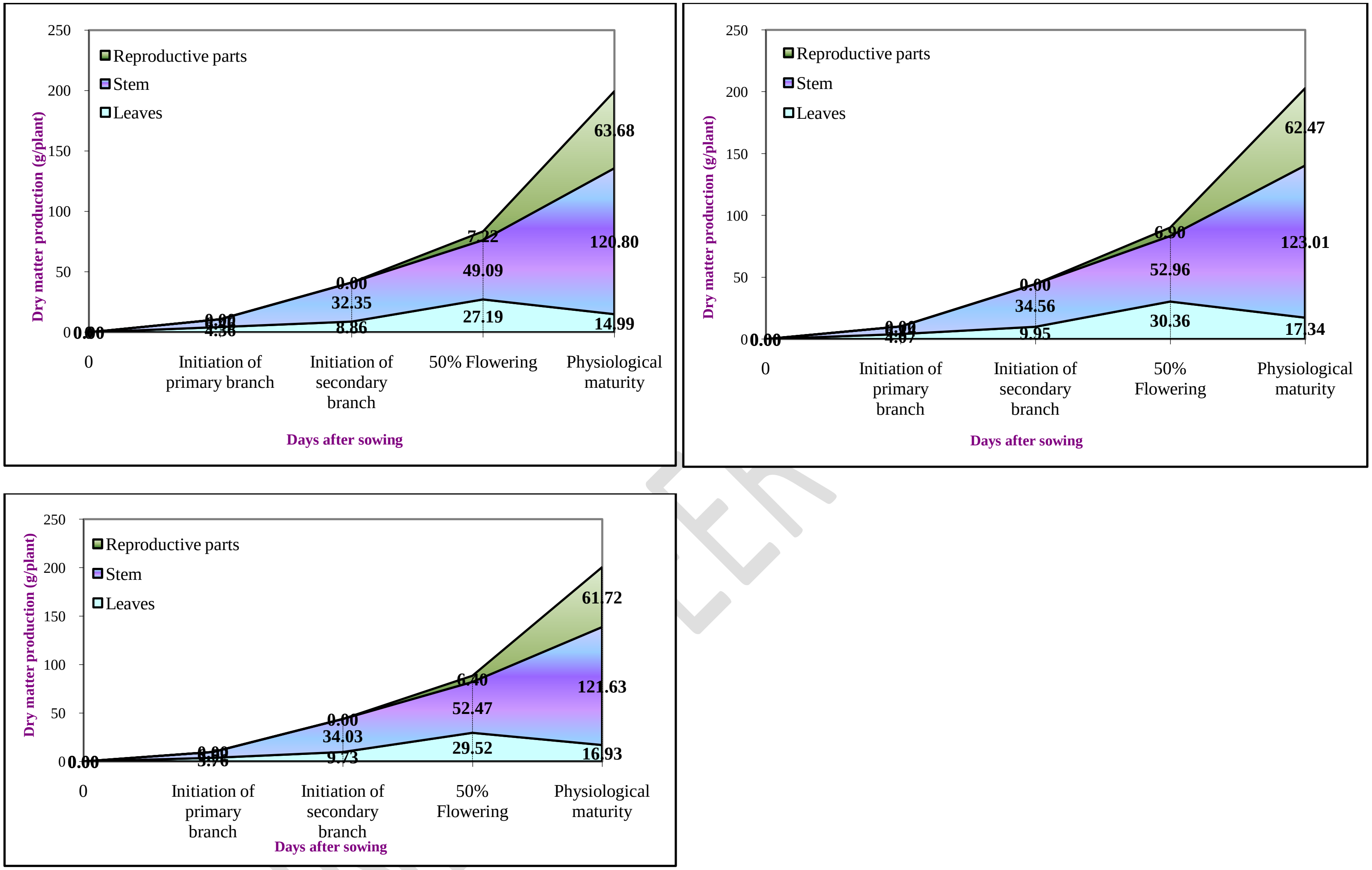

Fig. 2: Dry matter accumulation in different parts of pigeonpea genotypes