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**Research Paper**

# Optimizing sowing time of Spanish bunch groundnut (*Arachis hypogaea*) cultivars for spring-summer season in north-west India

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## ABSTRACT

A field experiment was conducted during the spring-summer seasons of 2018 and 2019 at Ludhiana, Punjab, to study the performance of groundnut (*Arachis hypogaea* L.) cultivars under different sowing dates. The experiment was laid out in 3 replications in a split-plot design with 4 sowing dates (25 February, 10 March, 25 March and 10 April) in main plots and 4 cultivars, viz. 'SG 99', 'TG 37A', 'TAG 24' and 'J 87' in subplots. The crop sown on 25 February took 6, 10 and 12 days more for emergence (17 days) and 11, 20 and 25 days more for maturity (133 days) than that sown on 10 March, 25 March and 10 April sowing dates, respectively. The highest pod yield (5.61 t/ha) was obtained from 10 March and oil yield (1.88 t/ha) from 25 February sowing date, whereas 10 April sowing resulted in the lowest pod yield (4.78 t/ha) and oil yield (1.43 t/ha). Gross returns, net returns and benefit: cost (B : C) ratio were the highest from 10 March-sown crop. Effect of sowing dates on yield attributes was variable. Cultivar 'J 87' gave the highest pod yield (5.78 t/ha), oil yield (1.96 t/ha), haulm yield (8.51 t/ha), resulting in higher gross returns and net returns than the other cultivars. 'TG 37A' gave higher pod yield than 'SG 99' and 'TAG 24' and the highest B : C ratio. Cultivar 'J 87' sown on 25 February gave significantly higher pod yield (6.73 t/ha) and oil yield (2.71 t/ha) than the other sowing dates. The highest pod and oil yields were recorded by 'SG 99' when sown on 25 February; by 'TG 37A' when sown on 25 March and by 'TAG 24' when sown on 10 March sowing date.

***Key words :*** Cultivars, Economics, Groundnut, Sowing dates, Yield

Groundnut is a unique blend of oil rich in oleic (48%) and linoleic (32%) acids, protein (26%, mainly lysine), carbohydrates and minerals (calcium, phosphorus, iron and zinc). Apart from use of kernels for extraction of oil, confectionery and direct consumption, its kernels are also used for extraction of milk. Kernel residues left after extraction of milk are used in preparation of cookies (Dharsenda and Dabhi, 2016). India exported groundnut worth about ₹38,980 million in 2018–19 mainly to south-east Asian countries (http://agriexchange.apeda.gov.in/product_profile/exp_f_india.aspx?categorycode=0501). There is tremendous scope for export of groundnut, particularly of confectionery types to European countries. Being a legume crop, groundnut enriches soil by fixing atmospheric nitrogen. Several studies have demonstrated the effect of time of sowing and duration of cultivars on growth and pod yield of groundnut (Sardana and Kandhola, 2007; Meena *et al*., 2015). In India, groundnut is grown during rainy (*kharif*), winter (*rabi*) and spring-summer seasons in different parts of the country. The productivity of groundnut sown in spring/summer and *rabi* seasons is higher as compared to *kharif* season (Upadhyaya *et al.,* 2005; Dutta, 2013). Cultivation of groundnut in spring-summer season under assured irrigation conditions in Punjab may provide better alternative to spring sunflower and maize owing to its higher yield potential and lesser water requirement. Multiple cropping is already practiced in Punjab on considerable area (cropping intensity 206%). There is dearth of information on cultivation of groundnut during spring/ summer season in North India in general and for Punjab in particular. Thus, there is a need to identify optimum sowing time and cultivars of groundnut for spring-summer season for the region to make it competitive to existing crops. Keeping in view the need for diversification, growing demand of groundnut, its higher yield potential during spring-summer season, the present study was conducted to study the effect of sowing dates on phenology, growth, yield attributes and yield of different Spanish bunch-type groundnut cultivars.

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## MATERIALS AND METHODS

A field experiment was conducted during spring-summer season of 2018 and 2019 at the research farm of Oilseeds Section, Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana (30°54' N and 75°48' E, 247 m above mean sea-level). The soil of experimental field was loamy sand, neutral in *p*H (7.2), normal in reaction (electrical conductivity, 0.23dS/m), low in organic carbon (0.15%), low in available nitrogen (125 kg/ha), medium in available phosphorus (12 kg/ha) as well as potassium (135 kg/ha). The study comprised 4 sowing dates (25 February, 10 March, 25 March and 10 April) and 4 Spanish bunch (*Arachis hypogaea* L. subsp. *fastigiata* Waldron var. *vulgaris* Harz) cultivars 'SG 99', 'TG 37A', 'TAG 24' and 'J 87' which were laid out as per split plot design, with sowing dates in main plots and cultivars in subplots in 3 replications. Gross and net plot size were 5.25 m × 3.0 m and 4.65 m × 1.80 m respectively. Cultivars were sown on experimental dates by dibbling 1 seed/hill at 30 cm row-to-row and 15 cm plant-to-plant spacing at depth of 4–5 cm. Recommended dose of N-P-K for Punjab (15 kg N, 20 kg $P_2O_5$ and 25 kg $K_2O$) were applied through urea, single superphosphate and muriate of potash, respectively, along with 125 kg gypsum/ha by broadcast at time of field preparation just before the last planking. Crop was sown after *kharif* groundnut–fallow. All other agronomic practices were followed as per package of practices of groundnut of the Punjab Agricultural University, Ludhiana.

Weather data were collected from the meteorological observatory, installed at the School of Climate Change and Agricultural Meteorology, PAU, Ludhiana, at a distance of about 400 metres from site of experiment. The maximum and minimum air temperatures during crop growth period varied from 25.8°C to 42.1°C and 12.2°C to 28.1°C, respectively, in 2018 and from 20.0°C to 43.0°C and 9.6°C to 28.5°C, respectively, in 2019. The maximum air temperature and sunshine hours were higher during early growth period (February–March) and lower during rest of the growth period in 2018 as compared to 2019 crop season. The total rainfall received during crop season in 2018 was 538.2 mm in 18 days and in 2019, it was 287.7 mm in 16 days. Rainfall during early crop growth was higher but during maturity was substantially lower in 2019 in comparison to 2018 crop-growth period.

Data on number of days required from sowing to emergence and physiological maturity were recorded. Five plants collected at random at physiological maturity were used to record plant height, number of gynophores and number of pods per plant. The number of nodules per plant was counted from 5 random plants at 40 and 70 days after sowing (DAS). After uprooting and subsequent drying of plants at maturity for 1 week, the plants were weighed before pods were stripped off from the plants to record haulm yield. Stripped pods were further sun-dried to moisture content below 10%. After harvesting and subsequent drying, number of kernels/pod was recorded on the basis of kernels obtained from 10 random pods from each treatment.

Shelling outturn was calculated by dividing the weight of kernels obtained from 250 g of mature pods. Oil content in kernels was determined by using Nuclear Magnetic Resonance Spectrophotometer (Benchtop oxford NMR analyzer, model MQC) and oil yield (kernel yield × oil content) was computed. Gross returns, net returns (calculated by subtracting total variable cost from the gross returns) and benefit: cost ratio were worked out for all treatments. Pooled mean data of phenology, different growth, yield attributes, yield and economics of 2 years are presented.

## RESULTS AND DISCUSSION

### *Sowing dates*

Number of days required for initiation of emergence by 25 February-sown groundnut (17 days) was significantly more than that required by 10 March-sown crop (11 days) which in turn took significantly more number of days for initiation of emergence than the crop sown on 25 March (7 days) and 10 April (5 days) (Table 1). Groundnut requires warm climates for its emergence and subsequent vegetative growth (Nelson, 1963). Cooler climatic conditions caused by lower air (both maximum and minimum) and soil temperatures, higher relative humidity and lesser number of sunshine hours in the subsequent days after sowing in early sowing dates resulted in slower pace of emergence than the later sowings. Higher temperature within the optimum range speeds up and the lower temperature slows down/inhibits the process of germination (Prasad *et al*., 2006). Mean number of days required for maturity decreased significantly with each delay in sowing from 25 February (133 days) to 10 March (122 days), 25 March (113 days) and 10 April (108 days).

Differences in plant height between successive sowing dates were non-significant except between 25 March and 10 March sowing dates. Congenial environmental conditions especially more favourable temperature during growth period in delayed sowing dates might have resulted in rapid cell-division in the meristematic tissues of the crop in comparison to early sowing dates where lower temperature might have slowed down or ceased the growth. Higher temperature promotes auxin synthesis which is responsible for cell division.

At 40 DAS, there was consistent increase in number of nodules/plant with each successive delay in sowing from 25 February to 25 March. Such increase in 10 March sowing date over 25 February sowing date was significant. However, at 70 DAS, differences in number of nodules/plant between different sowing dates were non-significant. Root nodules generally increased in number as the soil temperature increased. Better root growth provides more surface for infection thread formation which ultimately leads to the formation of more number of nodules. At maturity, there was a consistent reduction in number of gynophores (without pods)/plant with each successive delay in sowing from 25 February to 25 March, whereas it significantly increased in 10 April over 25 March sowing date (Table 1). In 25 February sowing date, favourable environmental conditions led to better transformation of individual early formed gynophores into pods but the gynophores formed at later stages failed to develop into pods probably due to resource constraints. There was consistent increase in total number of pods/plant with each successive delay in sowing from 25 February to 10 April with conspicuous increase in later sowing dates over 25 February sowing date (Table 1). Increase in temperatures particularly in the delayed sowing dates, probably hastened the process of development of pods which were set early in the crop-growth period, whereas the pods developed later failed to mature fully due to forced maturity and thus resulted in higher number of immature pods/plant.

Differences in number of kernels/pod between different sowing dates were non-significant (Table 1). Shelling outturn of 10 March-sown crop was significantly higher than that of 10 April-sown crop (Table 1). There was consistent reduction in 100-kernel weight with each successive delay in sowing, and such reduction in 25 March and 10 April sowing dates was significant over 25 February sowing date. Early-sown crop had longer crop duration and reproductive phase which offered enhanced period for development of kernels with higher mass and also got longer time for assimilation of photosynthates and their subsequent transfer to the developing pods (sink) as compared to delayed sowing conditions. Lower temperature in early-sown crop reduced the shell weight (Prasad *et al*., 2000) and increased kernel weight (Golembek and Johansen, 1997), which ultimately resulted in higher shelling percentage.

There was significant increase in biomass and haulm yields with each successive delay in sowings up to 25 March sowing date (Table 2). Biomass yield in 25 March sowing was 16.3, 5.8 and 5.2% higher than 25 February, 10 March and 10 April sowings, respectively. Increase in haulm yield in 25 March sowing over 25 February, 10 March and 10 April sowing dates was 32.0, 14.8 and 1.3% respectively. Higher air and soil temperatures in late sowings resulted in accumulation of more dry matter (of leaves and stems) by the plant at maturity as compared to early sowings. The highest pod yield was accrued from 10 March-sown crop (5.61 t/ha) which was statistically similar with that of 25 February (5.38 t/ha) and 25 March (5.33 t/ha) sowing dates and significantly higher than 10 April (4.78 t/ha) sowing date (Table 2). Early-sown crop had prolonged crop duration which resulted in higher biomass accumulation vis-a-vis photosynthetic area and probably resulted in enhanced translocation of photosynthates to reproductive organs. Longer reproductive phase in early sowing dates provided more time for development of pods

**Table 1.** Influence of sowing dates and cultivars on number of days taken for seedling emergence, maturity, growth and yield attributes of groundnut (mean of 2 years)

| Treatment | Days to initiation of emergence | Days to maturity | Plant height (cm) | Nodules/plant (No.) | | Gynophores/ plant at maturity | Pods/ plant | Kernels/ pod | Shelling out turn (%) | 100-Kernel weight (g) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 40 DAS* | 70 DAS* | | | | | |
| *Sowing dates* | | | | | | | | | | |
| 25 February | 17 | 133 | 37.4 | 22.4 | 73.8 | 20.9 | 47.6 | 1.92 | 71.5 | 67.0 |
| 10 March | 11 | 122 | 39.3 | 37.4 | 83.7 | 15.2 | 52.7 | 1.94 | 72.3 | 63.6 |
| 25 March | 7 | 113 | 44.7 | 38.9 | 86.0 | 14.4 | 54.3 | 1.99 | 70.6 | 62.5 |
| 10 April | 5 | 108 | 45.0 | 32.8 | 80.7 | 18.2 | 56.8 | 2.01 | 68.1 | 60.1 |
| SEm± | 0.06 | 0.19 | 0.74 | 2.36 | – | 0.91 | 0.97 | – | 0.70 | 0.88 |
| CD (P=0.05) | 0.18 | 0.58 | 2.3 | 7.29 | NS | 2.82 | 2.99 | NS | 2.15 | 2.70 |
| *Cultivars* | | | | | | | | | | |
| 'SG 99' | 10 | 123 | 48.9 | 26.7 | 78.0 | 21.7 | 49.2 | 1.90 | 69.1 | 61.2 |
| 'TG 37A' | 10 | 117 | 42.0 | 41.8 | 92.3 | 9.12 | 50.1 | 2.05 | 71.6 | 48.8 |
| 'TAG 24' | 10 | 118 | 36.5 | 29.3 | 77.3 | 20.4 | 55.5 | 1.97 | 69.1 | 54.7 |
| 'J 87' | 10 | 119 | 38.9 | 33.7 | 76.6 | 17.4 | 56.7 | 1.94 | 72.8 | 88.5 |
| SEm± | – | 0.25 | 0.87 | 1.70 | 3.72 | 0.68 | 1.03 | – | 0.65 | 0.87 |
| CD (P=0.05) | NS | 0.72 | 2.5 | 4.83 | 10.5 | 1.92 | 2.93 | NS | 1.86 | 2.46 |

*DAS, Days after sowing

and kernels than later sowing dates where the crop duration was reduced. Higher pod dry weight, shelling percentage and 100 kernel weight in early sowing dates resulted in higher pod yields. Similar effects of sowing dates of groundnut in different seasons were reported by Ahmed (1992), Baliarsingh and Mahapatra (2015) and Meena *et al*. (2015).

Crop sown on 25 February resulted in the highest oil yield (1.88 t/ha), being 11.8 and 23.6% (significantly) higher than 25 March and 10 April sowings respectively. Sardana *et al.* (2008) at same location and Mohite *et al* (2017) at Kolhapur also reported the similar effect of sowing dates on oil yield of *kharif* season groundnut.

The highest gross income (₹264 × $10^3$/ha), net returns (₹217 × $10^3$/ha) and benefit: cost ratio (4.63) were obtained from groundnut sown on 10 March. Crop sown on 10 April resulted in lowest gross returns, net income and benefit: cost ratio. Higher pod yield in early sowing dates manifested into higher gross income and net returns. Crop sown on 25 February, 10 March and 25 March resulted in better (4.36–4.63) benefit: cost ratio than 10 April-sown crop (3.83).

### *Cultivars*

There was no difference among cultivars for number of days required (10 days) for initiation of emergence (Table 1). Cultivar 'SG 99' took 123 days for maturity in comparison to 119, 118 and 117 days taken by 'J 87', 'TAG 24' and 'TG 37A' respectively (Table 1). Time taken by a cultivar for emergence depends on its vigour, relative pace of growth and its ability to perform under prevailing edaphic and environmental conditions. The obvious reason for similarity in emergence and maturity pattern could be that all these cultivars belong to same group, i.e. Spanish bunch type.

Cultivar 'SG 99' attained significantly more plant height than rest of the cultivars. Cultivar 'TG 37A' also attained significantly more height than 'J 87' and 'TAG 24'. Sardana and Kandhola (2007) had also reported differences in plant height of groundnut cultivars 'SG 99', SG 84 and 'M 522' during *kharif* season at Ludhiana. Cultivar 'TG 37A' produced significantly more number of nodules/plant at both 40 DAS and 70 DAS but significantly lesser number of gynophores at maturity than rest of the cultivars (Table 1) which indicated better efficiency of 'TG 37A' in developing the gynophores into pods. More number of gynophores at maturity in 'SG 99' and 'TAG 24' indicated higher potential of a cultivar to produce gynophore but poor efficiency to convert them into pods. These differences among cultivars may also be ascribed to differences in size of pods or kernels. Cultivar 'J 87' and 'SG 99' have larger pod size and probably required more energy for conversion into pods and further development of kernels. Cultivars 'TAG 24' and 'J 87' produced significantly more total number of pods/plant than 'SG 99' and 'TG 37A' (Table 1). Differences among cultivars for number of kernels/pod were non-significant (Table 1). Cultivar 'J 87' and 'TG 37A' attained significantly higher shelling percentage than that of 'SG 99' and 'TAG 24' (Table 1). Cultivar 'J 87' had significantly higher 100-kernel weight than all the other cultivars (Table 1).

Cultivar 'J 87' significantly outyielded 'SG 99', 'TG 37A' and 'TAG 24' for pod yield by margin of 14.0, 7.3 and 13.4%, respectively (Table 2). Kernel weight mainly contributed to higher yield of 'J 87' than the other cultivars. Cultivar 'TG 37A' (5.35 t/ha) gave 7.7 and 7.0% (significantly) higher pod yield than 'SG 99' and 'TAG 24', respectively. Oil yield of cultivar J 87 was 19.5, 10.7 and 23.4% higher than 'SG 99', 'TG 37A' and 'TAG 24' re-

**Table 2.** Influence of sowing dates and cultivars on yield and economics of groundnut (mean of 2 years)

| Treatment | Biomass yield (t/ha) | Pod yield (t/ha) | Haulm yield (t/ha) | Oil yield (t/ha) | Gross returns (×$10^3$/ha) | Net returns (×$10^3$/ha) | Benefit: cost ratio |
|---|---|---|---|---|---|---|---|
| *Sowing dates* | | | | | | | |
| 25 February | 11.37 | 5.38 | 5.99 | 1.88 | 252 | 206 | 4.38 |
| 10 March | 12.50 | 5.61 | 6.89 | 1.82 | 264 | 217 | 4.63 |
| 25 March | 13.23 | 5.33 | 7.91 | 1.65 | 251 | 205 | 4.36 |
| 10 April | 12.58 | 4.78 | 7.80 | 1.43 | 225 | 178 | 3.83 |
| SEm± | 0.17 | 0.11 | 0.13 | 0.05 | - | - | - |
| CD (P=0.05) | 0.52 | 0.33 | 0.41 | 0.11 | - | - | - |
| *Cultivars* | | | | | | | |
| 'SG 99' | 12.76 | 4.97 | 7.79 | 1.58 | 233 | 187 | 4.03 |
| 'TG 37A' | 12.20 | 5.35 | 6.85 | 1.75 | 252 | 208 | 4.67 |
| 'TAG 24' | 10.44 | 5.00 | 5.44 | 1.50 | 236 | 190 | 4.12 |
| 'J 87' | 14.29 | 5.78 | 8.51 | 1.96 | 272 | 221 | 4.37 |
| SEm± | 0.19 | 0.11 | 0.16 | 0.05 | - | - | - |
| CD (P=0.05) | 0.55 | 0.31 | 0.45 | 0.11 | - | - | - |

spectively. Cultivar 'TG 37A' gave 9.8% and 14.2% higher (significantly) oil yield than 'SG 99' and 'TAG 24' respectively. Sardana *et al.* (2008) also reported variation in oil yield among cultivars at the same location.

Differences among the cultivars for biomass and haulm yields were significant (Table 2). Cultivars 'J 87' provided significantly higher biomass yield (14.29 t/ha) and haulm yield (8.51 t/ha) than rest of the cultivars. Similarly 'SG 99' outyielded 'TG 37A' by 4.6% and 13.7% for biomass and haulm yields, respectively, and 'TG 37A' outyielded 'TAG 24' by 16.8% and 25.9% for biomass and haulm yields respectively. Meena *et al.* (2015) also reported the variation among cultivars for haulm yield.

Higher yields of 'J 87' contributed to its highest gross income (₹272 × $10^3$/ha) and net returns (₹221 × $10^3$/ha) followed by cultivar 'TG 37A'. The highest benefit: cost ratio (4.67) was obtained from 'TG 37A' followed by 'J 87' (4.37).

### *Sowing dates × cultivars*

Interaction between sowing dates and cultivars for pod yield was significant and there was consistent reduction in pod yield of 'SG 99' and 'J 87' with each delay in sowing dates from 25 February to 10 April (Table 3). Reductions in pod yield of 'J 87' were significant in 10 March over 25 February and in 10 April over 25 March sowing dates. Pod yields of 'SG 99' sown on 25 February and 10 March were significantly higher than 10 April sown crop. Pod yield of 'TG 37A' increased with delay in sowing up to 25 March though significantly up to 10 March. 'TAG 24' sown on 10 March gave significantly higher pod yield than 25 February and 10 April sowing dates. Pod yield of 'J 87' was significantly higher than the rest of cultivars in 25 February sowing date and significantly higher than 'SG 99' in 10 March sowing date. Cultivar 'TG 37A' significantly outyielded 'SG 99' and 'TAG 24' for pod yield in 25 March sowing date and that of 'SG 99' in case 10 April sowing date. Meena *et al*. (2015) also reported that, 'TG 37A' sown on 4 July exhibited significantly better yield - ttributing characters and consequently higher pod yield than all early sowing dates (20 April, 15 May and 9 June) at Bikaner, Rajasthan.

There was a consistent reduction in oil yield with each delay in sowing in case of 'J 87' whereas, oil yield increased up to 10 March sowing in 'SG 99' and 'TAG 24' and up to 25 March in 'TG 37A' (Table 3). Mean oil yield of 'J 87' in 25 February and 10 March sowing dates was significantly higher than the rest of cultivars. 'TG 37A' provided significantly higher oil yield than 'SG 99' and 'TAG 24' in 25 March sowing date and 'TAG 24' and 'J 87' in 10 April sowing date.

There was a consistent increase in haulm yield with each delay in sowing from 25 February to 25 March in 'SG 99', 'TAG 24' and 'J 87' and up to 10 April in 'TG 37A' (Table 3). Such differences in haulm yields were conspicuous between 10 March and 25 March sowings in 'SG 99', 'TG 37A' and 'J 87' cultivars and between 25 February and 10 March sowing in 'TG 37A' and 'TAG 24'. Meena *et al.* (2015) also reported lesser reduction in haulm yield in 'TG 37A' with delay in sowing (20 April, 15 May, 9 June and 4 July) as compared to 'HNG 10' at Bikaner, Rajasthan.

Cultivar 'J 87' sown on 25 February gave significantly higher pod yield (6.73 t/ha) than rest of the cultivars whereas it was at par with 'TG 37A' and 'TAG 24' in case of 10 March and with 'TG 37A' in case of 25 March sowing date. Sowing period of 10–25 March offers better en-

**Table 3**. Influence of sowing dates on pod, haulm and oil yields of groundnut cultivars (mean data of 2 years)

| Cultivars | Sowing dates | | | | SEm± | CD (*P*=0.05) |
|---|---|---|---|---|---|---|
| | 25 February | 10 March | 25 March | 10 April | | |
| *Pod yield (t/ha)* | | | | | | |
| 'SG 99' | 5.23 | 5.21 | 4.96 | 4.47 | 0.215 | 0.613 |
| 'TG 37A' | 4.85 | 5.59 | 5.73 | 5.24 | | |
| 'TAG 24' | 4.70 | 5.58 | 5.02 | 4.70 | | |
| 'J 87' | 6.73 | 6.05 | 5.60 | 4.73 | | |
| *Haulm yield (t/ha)* | | | | | | |
| 'SG 99' | 7.05 | 7.18 | 8.51 | 8.44 | 0.314 | 0.894 |
| 'TG 37A' | 4.63 | 6.67 | 7.86 | 8.23 | | |
| 'TAG 24' | 4.63 | 5.68 | 5.73 | 5.72 | | |
| 'J 87' | 7.65 | 8.05 | 9.52 | 8.82 | | |
| *Oil yield (t/ha)* | | | | | | |
| 'SG 99' | 1.62 | 1.68 | 1.59 | 1.42 | 0.073 | 0.217 |
| 'TG 37A' | 1.71 | 1.81 | 1.85 | 1.62 | | |
| 'TAG 24' | 1.46 | 1.74 | 1.49 | 1.32 | | |
| 'J 87' | 2.71 | 2.06 | 1.70 | 1.38 | | |

vironment for optimum yields of 'SG 99', 'TG 37A' and 'TAG 24' groundnut.

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