Evaluation of Soybean \([\text{Glycine max (L.) Merill}]\) for Phenology, Physiology, Growth, Productivity and Quality under Various Herbicidal Treatments

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**A B S T R A C T**

A research experiment was conducted at the Research Farm, Department of Agronomy, JNKVV, Jabalpur (M.P.) during Kharif season of 2018 which was laid out in a Completely Randomized Block design with three replications. Seven treatments comprised of combinations as well as single application of herbicides \(T_1\) (Propaquizafop @ 50 g ha\(^{-1}\)), \(T_2\) (Propaquizafop @ 60 g ha\(^{-1}\)), \(T_3\) (Propaquizafop @ 75 g ha\(^{-1}\)), \(T_4\) (Propaquizafop + Imazethapyr @ (75 + 50) g ha\(^{-1}\)), \(T_5\) (Quizalofop @ 70 g ha\(^{-1}\)), \(T_6\) (Hand weeding @ 20 and 40 DAS) and \(T_7\) (Weedy Check). The results revealed that treatment \(T_2\) had the longest (56.75 days) span of reproductive phase, whereas the treatment \(T_4\) had the shortest (55.25 days) span. \(T_2\) had the longest span of seed filling period (28.92 days). On the other hand, treatments \(T_4\) and \(T_5\) (27.33 days) indicated lowest time for seed filling duration. \(T_6\) recorded maximum biological yield (16.44 g plant\(^{-1}\) and 5479 kg ha\(^{-1}\)) which ultimately reflected in its maximum seed yield (5.74 g plant\(^{-1}\) and 1912 kg ha\(^{-1}\)). The maximum fat (21.16\%), carbohydrates (18.76\%) and ash contents were registered in treatment \(T_6\) (5.64\%), whereas crude fiber (8.34\%) and proteins (40.12\%) were registered in \(T_4\).

**Keywords**

Propaquizafop, Quizalofop, Imazethapyr, Hand weeding, Yield

**Introduction**

Soybean \([\text{Glycine max (L.) Merill}]\) is known as the "GOLDEN BEAN" of the 20\(^{th}\) Century. It accounts approximately 50\% of total production of oilseed crops in the world. It has emerged as one of the important commercial crops in many countries. Soybean is also known as the “Miracle Crop” because of its multiple uses and qualities as it has been used as pulse as well as oilseed crop. It has great potential as an exceptionally nutritious and very rich protein food. Soybean contains 35-40\% protein, 19\% oil, 35\% carbohydrate (17\% of which is a dietary fibre), 5\% minerals and several other components including vitamins (Liu, 1997). Owing to its amino acids composition, the protein of soybean is called a complete protein. In India, soybean cultivation is done in 10.56 million hectares with the annual production of 11.39 million metric tons and average productivity of 1078.6 kg hectare\(^{-1}\) (MOA & FW, 2018). Among different states of India, Madhya
Pradesh occupies the first position in area i.e. 54.09 lakh hectares and production of 59.17 lakh million tons with average productivity of 1094 kg ha⁻¹ (SOPA, 2018). In M.P., farmers apply high seed rate and narrow spacing of plant and rows to avoid risk of less plant population. Farmers in field apply more than 25 per cent more seed than needed. This is because of poor equipment or lack of calibration. Some of it is just habit, but some producer feels that the high seeding rates are needed for better weed control. The low productivity of the crop in the state is due to several constraints, one of the major constraints in soybean production is crop-weed competition (Vollmann et al., 2010); being a rainy season crop, as it is heavily infested with grasses, sedges and broadleaved weeds. The weed control practices have been exercised for the long time. Recently developed herbicides response to the weeds, crop physiological traits, productivity and quality aspects in soybean needs to be ascertained. Keeping in view of the above facts, the present investigations are undertaken

Materials and Methods

An experiment was conducted to evaluate the effect of various herbicidal treatments on phenophasic development and productivity with biochemical aspects in soybean during Kharif season of the year 2018 at the Research Farm of Department of Agronomy, JNKVV, Jabalpur (M.P.). Estimation of biochemical constituent was done in the laboratory of the Department of Plant Physiology, JNKVV, Jabalpur. The seven weed control treatments comprising of T₁ (Propaquizafop @ 50 g ha⁻¹), T₂ (Propaquizafop @ 60 g ha⁻¹), T₃ (Propaquizafop @ 75 g ha⁻¹), T₄ (Propaquizafop + Imazethapyr @ (75 + 50) g ha⁻¹), T₅ (Quizalofop @ 70 g ha⁻¹), T₆ (Hand weeding @ 20 and 40DAS) and T₇ (Weedy Check) were laid out in Completely Randomized Block Design with three replications. Seeds and soybean (JS 20-29) were sown in the field adopting recommended cultural practices. The phenological observations were noted from three selected and tagged plants throughout the growth period through daily visual observations.

The ash content in the seed sample was estimated according to AOAC (1980). Total carbohydrates in the samples were estimated by the method as described by Sadasivam and Manickam, 1992. The nitrogen content was estimated by micro Kjeldhal method (A.O.A.C., 1980) and the fat content in the sample was estimated by pelican equipment/socs plus based on principle of Soxhlet’s extraction method as described in AOAC (1980). The seed yield g plant⁻¹ and kg ha⁻¹ was recorded after threshing, cleaning and drying the seeds. It is also known as economical yield. Biological yield is the total yield of crop including economic yield and the straw yield. The biological yield per plant was recorded after harvesting.

Results and Discussion

Phenophases

Days to flower initiation

The investigations (Table 1) indicated that treatments T₃, T₅ and T₆ (35.00 days) acquired minimum days to attain flower initiation stage which is a beneficial trait for prolonging the reproductive phase. On the other hand, treatment T₁ (36.00 days) took the maximum time to record flower initiation. It is worthwhile to indicate that the treatments had not too much variation for this trait. The seed yield was positively and directly influenced by days of flower initiation (Kumar et al., 2012).
Table.1 Phenophases in soybean during reproductive growth period under different herbicidal treatments

| Treatments                                      | Days to flower initiation | Days to 50% flowering | Days to completion of flowering | Days to pod formation | Days to seed Formation | Days to physiological maturity | Days to maturity |
|------------------------------------------------|---------------------------|-----------------------|---------------------------------|------------------------|------------------------|--------------------------------|------------------|
| T1 = Propaquizafop @ 50 gha⁻¹                   | 36.00                     | 39.50                 | 46.75                           | 55.25                  | 64.25                  | 76.25                          | 92.42            |
| T2 = Propaquizafop @ 60 gha⁻¹                   | 35.67                     | 37.67                 | 48.75                           | 54.25                  | 63.50                  | 76.75                          | 92.42            |
| T3 = Propaquizafop @ 75 gha⁻¹                   | 35.00                     | 39.00                 | 47.75                           | 54.25                  | 64.75                  | 76.75                          | 91.42            |
| T4 = Propaquizafop + Imazethapyr @ (75+50) gha⁻¹| 35.33                     | 39.00                 | 48.25                           | 55.25                  | 63.25                  | 78.75                          | 90.58            |
| T5 = Quizalofop @ 70 gha⁻¹                      | 35.00                     | 38.00                 | 47.75                           | 54.25                  | 64.25                  | 76.25                          | 91.58            |
| T6 = Hand Weeding @ 20 and 40 DAS               | 35.00                     | 38.00                 | 48.50                           | 55.75                  | 62.50                  | 75.75                          | 90.58            |
| T7= Weedy Check                                 | 35.00                     | 39.00                 | 46.25                           | 52.25                  | 64.50                  | 75.25                          | 91.08            |
| SEm±                                           | 0.22                      | 0.34                  | 0.47                            | 0.46                   | 0.51                   | 0.47                           | 0.39             |
| CD 5%                                          | 0.68                      | 1.06                  | 1.45                            | 1.41                   | 1.57                   | 1.43                           | 1.19             |

Table.2 Productivity in soybean under various herbicidal treatments with biochemical constraints

| Treatments    | Ash (%) | Crude fiber (%) | Carbohydrate (%) | Protein (%) | Fat (%) | Seed yield | Biological yield |
|---------------|---------|-----------------|------------------|-------------|---------|------------|------------------|
|               |         |                 |                  |             |         | g plant⁻¹ | Kg ha⁻¹          | g plant⁻¹ | Kg ha⁻¹ |
| T1            | 5.24    | 6.37            | 17.56            | 38.06       | 18.23   | 3.40       | 1132             | 11.15     | 3716    |
| T2            | 4.88    | 6.14            | 17.81            | 38.43       | 19.28   | 4.92       | 1640             | 15.71     | 5237    |
| T3            | 5.23    | 8.12            | 18.39            | 38.36       | 19.45   | 5.09       | 1698             | 15.69     | 5231    |
| T4            | 5.12    | 8.34            | 18.48            | 40.12       | 20.57   | 5.50       | 1832             | 16.02     | 5340    |
| T5            | 5.26    | 6.52            | 17.77            | 38.63       | 18.88   | 4.30       | 1434             | 12.99     | 4329    |
| T6            | 5.64    | 7.65            | 18.76            | 39.3        | 21.16   | 5.74       | 1912             | 16.44     | 5479    |
| T7            | 4.89    | 6.43            | 16.44            | 37.09       | 17.35   | 2.20       | 732              | 8.38      | 2792    |
| SEm±          | 0.07    | 0.23            | 0.34             | 0.45        | 0.26    | 0.23       | 49.66            | 0.50      | 109.54  |
| CD 5%         | 0.23    | 0.69            | 1.05             | 1.37        | 0.81    | 0.71       | 153.0            | 1.56      | 337.54  |
The results showed (Table 1) that treatments T₃, T₄ and T₇ (39.00) required maximum time for completion of 50% flowering. On the other hand, lowest time was recorded in T₂ (37.67). This suggested that the treatments didn’t indicate a similar pattern in respect of days to flower initiation and completion of 50% flowering. The pattern of flower production, pod retention, number of flowers produced and percentage of flowers and pods abscised varied with cultivars (Zaiter and Barakat, 1995).

The investigations indicated (Table 1) that treatment T₇ (46.25 days) took minimum time for completion of flowering, whereas treatment T₂ (48.75 days) required maximum time for completion of flowering.

The pattern from flower initiation to completion of flowering responded variably in different treatments. Flowering was started at 45 to 50 DAS, depending on genotypes (Khan and Khalil, 2010).

Treatment T₆ (55.75 days) registered (Table 1) maximum time for formation of pods. On the other hand, T₇ (52.25 days) needed minimum time to attain this stage. Earlier investigations showed that early pod formation resulted in high productivity which contradicts the result of present investigations.

The weed competition is one of the most important causes of yield loss (30 to 80%) in kharif soybean and modification in source sink balance could increase assimilates distribution towards the pods (Yaduraju, 2016).

The present study showed (Table 1) that treatment T₆ (62.50 days) had the earliest seed formation which is a beneficial trait for enhancing economic productivity in crop plants. However, treatment T₃ (64.75 days) had delayed seed formation. Normally early seed formation is positively correlated with the seed productivity provided the seed filling rate is at optimum speed.

In the present study (Table 1), treatment T₇ (75.23 days) recorded the minimum and T₄ (78.75 days) maximum time to achieve this stage. The real physiological maturity may be advantageous if the seeds are harvested at that particular stage (Gontia et al., 1995).

The study showed (Table 1) that treatments T₄ and T₆ (90.58 days) attained the maturity earliest which has the advantage of avoiding shattering which sometimes takes place when the crop is harvested at the later stages. Treatment T₁ and T₂ (92.42 days) took maximum time for reaching the maturity. The seed yield plant⁻¹ was found to be significantly and positively correlated with days to maturity (Kumar et al., 2004). Among morphological traits under water stress conditions, the days to maturity showed the maximum reduction (94%) (Shadakshari et al., 2014).

The results indicated (Table 2) that all the treatments significantly increased seed yield in soybean. The results were in accordance with the findings of Deore et al., (2007), Pradhan et al., (2010) and Tuti and Das (2011). The improvement in the yield and
economic parameters were obtained under different weed management practices in soybean (Raskar and Bhoi, 2002).

**Biological yield (g plant$^{-1}$ and kg ha$^{-1}$)**

The present study (Table 2) indicated that the treatments T$_6$ (16.44 g plant$^{-1}$ and 5479 kg ha$^{-1}$) and T$_7$ (16.02 g plant$^{-1}$ and 2792 kg ha$^{-1}$) recorded higher magnitudes for biological yield. It is further mentioned that higher biological yield is not always indicative of higher economic yield as it depends on allocation of photosimilates into the vegetative or reproductive parts of the plant.

Under herbicidal treatments the highest seed yield (24.46 qha$^{-1}$) and straw yield of soybean were also recorded in Imazethapyr @ 0.100 kg a.i. ha$^{-1}$ + Quizalofop ethyl @ 0.075 kg a.i. ha$^{-1}$ as PoE (Prachand et al., 2014).

**Biochemical constituents**

**Ash (%)**

The present study (Table 2) indicated that treatment T$_6$ (6.54%) recorded the highest and T$_2$ (4.88%) lowest ash contents, respectively. In ten vegetable soybean genotypes along with the control the ash content was ranged from 1.49-1.74 % (Salmani et al., 2012).

**Crude fiber (%)**

In ten vegetable soybean genotypes along with the control the fiber content was ranged from 1.89-2.69 %. On the other hand, in the present investigations (Table 2), the crude fiber was found to be in the range of 8.34% in T$_4$ and 6.4% in T$_2$, respectively.

**Carbohydrate (%)**

The present study (Table 2) indicated that the treatments T$_6$ (18.76%) and T$_4$ (18.48%) recorded the higher magnitudes which is beneficial trait for all the aspects. The carbohydrates provide the energy for growth and various functions in the plant. In ten vegetable soybean genotypes along with the control the carbohydrate content was ranged from 5.88-7.93 % (Salmani et al., 2012).

**Protein (%)**

The protein is very important for maintaining structural integrity of plant cells and also acts as energy source under starvation. The present study (Table 2) indicated that treatments T$_4$ (40.12%) and T$_6$ (39.3%) had the higher magnitudes for protein contents, whereas treatment T$_7$ recorded the minimum (37.09%). However, Salmani et al., (2012) reported 12.32 - 14.96 % protein content in ten vegetable soybean genotypes. The dry matter and yield components had strong negative association with protein content. Variety Awassa-95 (45%) recorded significantly higher protein contents than variety Belessa-95 (40%) (Pal et al., 2012).

**Fat (%)**

The present investigations showed (Table 2) that treatment T$_7$ had the maximum (21.16) fat %, whereas the lowest (17.35%) was found in T$_7$. The promising varieties of soybean have been found to contain the oil in the range of 19-24 percent oil concentrates increase both herbicidal effectiveness and the possibility of soybean injury (Ariunaa et al., 2016). The yield obtained by early planting was positively correlated with the oil contents (Naoki et al., 2016).

In conclusion the studies pertaining phenophases indicated that treatment T$_2$ had the longest (56.75 days) span of reproductive phase, whereas the treatment T$_4$ had the shortest (55.25 days) phase of reproductive phase. T$_2$ had the longest span of seed filling.
period (28.92 days). On the other hand, treatments T₄ and T₅ (27.33 days) indicated lowest time for seed filling duration. Treatment T₆ (Hand Weeding @ 20 and 40 DAS) out yielded maximum seed yield (5.74 g plant⁻¹ and 1912 kg ha⁻¹) and biological yield (16.44 g plant⁻¹ and 5479 kg ha⁻¹). Treatment T₄ (Propaquizafop + Imazethapyr @ (75 + 50) gha⁻¹) was adjudged the second in yield performance (5.50 g plant⁻¹ and 1912 kg ha⁻¹) and biological yield (16.02 g plant⁻¹ and 5340 kg ha⁻¹). Treatment T₇ indicated the lowest yield (2.20 g plant⁻¹ and 732 kg ha⁻¹) owing to poor performance of all yield components. The maximum fat (21.16%), carbohydrates (18.76%) and ash contents were registered in treatment T₆ (5.64 %), whereas crude fiber (8.34 %) and proteins (40.12 %) were in T₄.

**Acknowledgement**

The Authors are thankful to Department of Plant Physiology and Department of Agronomy, JNKVV, Jabalpur for their helpful and constant guidance during the course of investigation.

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How to cite this article:

Supriya Debnath, A. S. Gontia, Mrunal Ghogare, A. K. Jha, Anubha Upadhyay, Preeti Sagar Nayak and Zuby Gohar Ansari. 2020. Evaluation of Soybean [Glycine max (L.) Merill] for Phenology, Physiology, Growth, Productivity and Quality under Various Herbicidal Treatments. Int.J.Curr.Microbiol.App.Sci. 9(08): 2176-2182.

doi: https://doi.org/10.20546/ijcemas.2020.908.248