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Effect of seed priming and urea foliar application on the performance of soybean (*Glycine max* L. Merrill)

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Abstract
The field experiment entitled "Effect of seed priming and urea foliar application on the performance of the soybean (*Glycine max* L.)*"* was conducted at Research Farm of University College of Agriculture, Guru Kashi University, Talwandi Sabo, Bathinda during *kharif* season 2019. The trail was laid out in split plot design with two levels of foliar application of urea (control, 2%) at 60 and 75 DAS, in main plots and four seed priming levels (0,3,6 and 9hours, duration) in sub plots, replicated thrice. 2% foliar application of urea recorded significantly higher emergence count plants m^{-1} row length(12.84), plant height cm (127.8), dry matter accumulation g $plant^{-1}$ (78.61), number of leaves $plant^{-1}$ (90.85), number of branches $plant^{-1}$ (9.44), number of pods $plant^{-1}$ (87.68), number of seeds pod^{-1} (2.85), test weight g(100), grain yield q ha^{-1} (30.96), straw yield q ha^{-1} (56.08) and biological yield q ha^{-1} (87.05) than other control treatment, Seed priming at 9 hr q ha^{-1} (31.07) resulted in higher grain yield than 0, 3 and 6 hr respectively. The emergence count plants m^{-1} row length (12.67), plant height cm (126.5), dry matter accumulation g $plant^{-1}$ (78.07), number of leaves $plant^{-1}$ (89.90), number of branches $plant^{-1}$ (9.53), number of seeds pod^{-1} (2.95), test weight g(100), grain yield q ha^{-1} (31.07), straw yield q ha^{-1} (54.56) and biological yield q ha^{-1} (85.63) was recorded significantly higher 9 hour priming treatment but it was at par with the application of seed priming 6 hr. The application of 9hr seed priming found maximum grain yield q ha^{-1} (31.07) resulted in 7.4, 4.2 and 2.7% higher grain yield than 0, 3 and 6hr seed priming respectively.

Keywords: Foliar application, grain yield, seed priming and soybean

Introduction
Soybean (*Glycine max* L.) is a member of leguminosae family, rich in nutrients and it is regarded as a nutrient storage. Soybean is not only seen as an oil plant but also used for various purposes. Among grain legumes, soybean is an economically important crop that is grown in diverse environments throughout the world. Soybean is one of the most important protein and oil crop throughout the world. Its oil is the largest component of the world's edible oils. Soybean seed contains 18-22% oil and 40-48% protein. The world production of edible oils consists of 30% soybean. It is an ingredient of more than 50% of the world's high protein meal. Soybean has industrial application due to its nutraceutical and pharmaceutical benefits. The global demand of food grade soybeans is on the increase in both traditional Asian markets and new world markets. The origin of soybean is reported to be eastern Asia or China. The leading soybean growing countries are USA, Brazil, China, Argentina, and India respectively, and in India, area under soybean cultivation is 9.51 million hectares with a production of 9.91 million tonnes and productivity are 1.04 tonnes ha^{-1}. Nearly 54% is produced in the states of Madhya Pradesh. Other leading states are Maharashtra, Rajasthan and Andhra Pradesh. These states together accounts for 95% of the total area and production of soybean, respectively. In Punjab, soybean occupied an area of 0.22 million hectares with production of 0.21 million tones and productivity 0.95 million tones and the seed yield of soybean ranged from 21 q ha^{-1} (Anonymous 2020).

Foliar application of nutrients constitutes one of the important milestones in the progress of agricultural production. Fertilizer applied to the crop at the time of sowing is not fully available to the plants as the crop approaches maturity so supplemental foliar application is one of the techniques to increase yield of the crop. The use of alternative fertilizers application strategies to achieve maximum yields and enhance nutrient use efficiency has been proposed for decades with the increase in soybean yields due to important genetic improvements, demand for nutrient has also increased. Increased nutrient demands from more intensive cropping practices and high yielding potential crops may also require additional micronutrient for optimum yields. Supplementary foliar application of N, P, K and micronutrients for deficient soils can help to enhance the crop yields under these conditions. Foliar spraying is a new method for crop feeding in which micronutrients in the form of liquid are used into leaves (Nasiri *et al.* 2010) [13].

Foliar application of major and micronutrients like NPKS and B was found to be more advantageous than soil application and also avoiding the depletion of these nutrients in leaves, thereby resulting in an increased photosynthetic rate, better nutrient translocation of these nutrients from the leaves to the developing seeds. Foliar application is credited with the advantage of quick and efficient utilization of nutrients, elimination of losses through leaching and fixation and helps in regulating the uptake of nutrients by plants (Manonmani and Srimathi 2009) [12].

Seed priming has presented promising, and even surprising results, for many seeds including the legume seeds. Priming in its traditional sense, soaking of seeds in water before sowing, has been the experience of farmers in India in an attempt to improve crop stand establishment but the practice was without the knowledge of the safe limit of soaking duration (Harris, 1996) [7].

Effect of seed priming on storability, field performance, and seed quality of soybean seed priming has been successfully demonstrated to improve germination and emergence in seeds of many crops, particularly seeds of vegetables and small seeded grasses. The beneficial effects of priming have also been demonstrated for many field crops such as wheat, sugar beet, maize, soybean and sunflower (Khajeh-Hosseini *et al.* 2003) [10]. The germination of soybean is major problem faced by seed producer and farmers. The improvement in seed quality by invigoration treatments is attributed to primary induced reduction of lipid per oxidation and quantitative changes in biochemical activities including amylase activity increasing per cent sugar during germination. Farmers are very much reluctant to apply basal dose of fertilizer in pulse crops the situation is more prominent under for lathyrus, which ultimately results in poor yield.

Material and Methods

The present investigation entitled "Effect of foliar application of urea and seed priming on the performance of the soybean (*Glycine max* L.)*"* was conducted at Guru Kashi University, Talwandi Sabo (Bathinda). It is situated between 29.990 N latitude and 75.080 E longitude with an altitude of 252 meters above the mean sea level. The experimental site belongs to sub-tropical semi-arid climate having extreme winters and summers.

The experimental site belongs to semi-arid climate, where both summers and winters are acute. A maximum temperature of about 45º is very common during summer, while freezing temperature accompany by frost happening may be in the months of December and January.

The monsoon season normally starts from the first week of July. However, a few showers received during winter season also. The temperature and rainfall both were found to be optimum for cotton crop.

The soil was slightly alkaline (pH 8.70) with normal electrical conductivity (0.42 dSm^{-1}). The soil was medium in organic carbon content (0.40%). The available nitrogen (135.0 kg ha^{-1}) was low, whereas the available phosphorus (14.4 kg ha^{-1}) and available potassium (230 kg ha^{-1}) were both medium. The experiment was laid out in split plot design with three replications. The treatments comprised of two levels of urea foliar application (control, 2%) and four levels of seed priming at (0, 3, 6 and 9 hrs). Data on days to 50% emergence were calculated from the date of sowing and date of 50% emergence by counting seedling emergence in each plot daily. Emergence data was recorded by counting number of plants emerged in one meter row length at two randomly selected rows in each plot.

The height (cm) of five randomly selected plants was measured at maturity. Dry matter accumulation was recorded from each plot, one plant was selected at random from a row ear marked for destructive sampling was uprooted and different plant parts *viz.* stem and leaves were separated. These samples were first air-dried and then oven dried to constant weight at 65^0 C in hot air oven and their by weight was recorded. The trifoliate functional leaves $plant^{-1}$ of five randomly selected plants was measured at maturity, were counted on five tagged plants.

The average value was recorded as number of pods $plant^{-1}$ was counted on five randomly selected plants in each plot. Grain yield from harvesting was weighed separately and obtained by totaling these in kg $plot^{-1}$ was calculated and converted it into q ha^{-1}. The total weight of crop biomass from each plot was weighed separately and straw yield in kg $plot^{-1}$ was calculated and converted it into q ha^{-1}. The biological yield obtained from the addition of grain yield and straw yield.

Results and Discussion

Growth parameters of soybean

The interaction effect between foliar application of urea and seed priming duration on emergence count/ m row length of soybean was found to be a non- significant. The emergence count/ m row length was observed significantly higher with application of foliar application (12.8 m row length) than other treatments. The emergence count/ m row length was observed with application of control (11.5 m row length). Foliar nutrition has been proved to be effective, particularly for the areas where soil application of fertilizers often leads to locking or loss of nutrients. Foliar application is regarded as a preferred solution when quick supply of nutrients is hindered or the soil conditions are not conducive for the absorption of nutrients (Salisbury and Ross, 1985) [16]. The emergence count/m row length was observed significantly higher with application of seed priming at 9hr (12.6 m row length) than other treatments. The emergence count/ m row length was observed with application of control (11.7 m row length).but it was statistically at par with seed priming at 6hr (12.4 m row length) respectively. The interaction effect between foliar application of urea and seed priming duration on emergence count/ m row length of soybean was found to be a non-significant. Harris *et al.* (1999) [8] also reported that the seed priming increased seedling emergence, plant height, number of pods, seed weight, grain yield and straw yield of chickpea and also found significantly results of seed priming in maize and rice crop. Ghosh *et al.* (1997) [6], who reported the highest germination, improved emergence and good stand establishment in the field trials of seed priming as compared to control.

Table 1: Effect of different levels of foliar application of urea and seed priming duration on growth parameters of soybean.

Treatment	Emergence count/m row length	Plant height (cm)	Trifoliate functional leaves ($plant^{-1}$)	Dry matter accumulation (g $plant^{-1}$)
Foliar application				
Control	11.5	119.63	77.7	71.31
2% urea	12.8	127.87	90.8	78.61
LSD (P=0.05)	0.6	1.03	6.27	1.43
Seed priming				
0	11.7	121.13	79.5	71.98
3	11.9	123.30	81.5	73.67
6	12.4	124.05	86.3	76.12
9	12.6	126.52	89.9	78.07
LSD (P=0.05)	0.5	1.54	2.55	0.69
Interaction	NS	NS	NS	NS

The interaction effect between foliar application of urea and seed priming duration on plant height of soybean was found to be non-significant. There was significant effect of foliar application on plant height cm (127.8cm). The lowest plant height (119.6 cm) was observed with control. The highest plant height (127.8 cm) was observed with application of 2% foliar application of urea, which was significantly higher than control.

Table 2: Effect of different levels of foliar application of urea and seed priming duration on yield attributes of soybean

Treatment	Number of pods $plant^{-1}$	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})
Foliar application				
Control	60.0	29.05	44.73	73.78
2% urea	87.6	30.96	56.08	87.05
LSD (P=0.05)	17.4	1.7	3.0	4.7
Seed priming				
0	62.0	28.91	45.39	74.31
3	76.8	29.81	49.19	79.00
6	69.9	30.24	52.49	82.73
9	86.6	31.07	54.56	85.63
LSD (P=0.05)	NS	1.3	2.3	3.7
Interaction	NS	NS	NS	NS

The increase in plant height due to spraying of nutrients increases plant height this could be attributed due to involvement of nutrients in plant cell, cell wall, and translocation of plant nutrients to growing plant and thereby increase in photosynthetic efficiency by delaying the leaf senescence. Similar results were obtained by Kaur *et al.* (2015) [11] amongst all the treatments 2 per cent urea spray application caused maximum increase in growth attributes *viz*., plant height. These growth attributes showed significant positive correlation with yield. The results are in line with Kalarani *et al.* (1991) [9] also reported that foliar spray of 2% urea recorded higher plant height (68 cm), LAI (966.5 cm2) at pod filling stage. The response of urea @ 0.2% (T6) was found to be superior as compared to KNO_3 @ 0.1% (T8) and $ZnSo_4$ 0.5 per cent (T4) in increase in plant height. There was significant effect of seed priming on plant height (126.5 cm) was recorded in seed priming 9hr. The lowest plant height (121.1 cm) was observed with application of control. The observed increase of plant height and in priming treatments may be due to the improved establishment of seedling, minimization of time between seed sowing and emergence and the synchronization of emergence, and promoted use of nutrient and soil moisture Valadkhan *et al.* (2015) [19].

The interaction effect between foliar application of urea and seed priming duration on trifoliate functional leaves $plant^{-1}$of soybean was found to be a non- significant. The highest trifoliate functional leaves $plant^{-1}$ was obtained with application of 2% foliar application of urea (90.8 $plant^{-1}$) respectively. It was significant higher than control. The lowest trifoliate functional leaves plant-^{1} was observed with application of control (77.7$plant^{-1}$). The maximum number of leaves and leaf area $plant^{-1}$ was observed with the application of thiourea spray @ 0.1% at 30 and 45 DAS (T4) at all the growth stages. Which was closely followed by KNO_3 spray @ 1% at 30 and 45 DAS (T8), 19:19:19 spray @1% at 30 and 45 DAS (T10) and Thiourea spray @ 0.1% at 30 DAS (T3) This might be due to thiourea helped in rapid cell multiplication and resulted in expansion of leaf area thereby accelerating the photosynthetic rate and concentration of total chlorophyll ultimately increased all growth parameter These results are in conformity with the results obtained by Sahu and Solanki (1991) [15]. The number of trifoliate functional leaves $plant^{-1}$ was significant the highest trifoliate functional leaves $plant^{-1}$ was obtained with application of seed priming 9hr (89.9 $plant^{-1}$). It was significant higher than control. The lowest trifoliate functional leaves $plant^{-1}$ was observed with application of control (79.5 $plant^{-1}$) but at par with the application of seed priming 6hr (83.6). Since it was found that hydro-priming affected the phonological stages of growth like plant height, dry matter accumulation, number of leaves, flowering the role of the indeterminate chickpea growth in this case was not good; although flowering in the suitable environmental condition can produce the number of fertile flowers and consequently more pods Nonetheless, Tomar *et al.* (1982) [17].

Yield attributes of soybean

The interaction effect between 2%foliar application of urea and seed priming duration on test weight (g) of soybean was found to be a non-significant. Highest number of pods (87.6 $plant^{-1}$) was produced by treatment 2% foliar application of Urea. Which was significantly higher than other treatments except control, the minimum pods $plant^{-1}$ (60.0 $plant^{-1}$) were produced? Higher supply of all nutrients at flower initiation and pod formation stages of crop growth might have caused efficient translocation of photosynthesis from source to sink. The results obtained by Gomathi (1996) [5] that foliar spray of 1 percent urea increased the number of pods significantly in green gram. The number of pods $plant^{-1}$was non-significant effect by seed priming application. The highest number of pods (86.6 $plant^{-1}$) was observed with the application of seed priming at 9hr.The lowest number of number of pods (62.0 $plant^{-1}$) was observed with control application respectively. Bastia *et al.* (1999) [3] reported that the use of hydro-priming treatment in safflower increased the number of heads $plant^{-1}$, the number of seeds $head^{-1}$, and the seed thousand weight and yield. Moreover, the cause of differences in the number of pods in plant could be due to the prolonged period of bloom and pod formation at the right time. Since it was found that hydro-priming affected the phonological stages of growth, the role of the indeterminate chickpea growth in this case was not good; although flowering in the suitable environmental condition can produce the number of fertile flowers and consequently more pods.

The interaction effect between foliar application of urea and seed priming duration on grain yield (kg ha^{-1}) of soybean was found to be a non- significant. The grain yield was observed significantly higher with application of 2% foliar application of urea (30.9 q ha^{-1}) than other treatments. The lowest grain yield was observed with application of control (29.0 q ha^{-1}). It was concluded that grain yield accumulation of soybean was affected significantly through different treatments at flowering and pod formation stages foliar feeding of nutrients like N, K and Zn to plants altered metabolic activities due to hormonal effects. nutrient elements play a critical role in plants that lead to leaf area index and there by increased light absorption and increase the amount of dry matter accumulation and economic yield. Venkatesh and Basu (2011) [18] concluded that foliar application of urea apart from the basal application of RDF increased The highest grain yield and yield attributes were recorded with 2 per cent urea spray at 75 days after sowing. The grain yield was observed significantly higher with application of seed priming at 9hr (31.0 q ha^{-1}) than other treatments. But, it was statistically at par with the application of seed priming at 3hr and 6hr (29.8 and 30.2 q ha^{-1}). The lowest grain yield was observed with application of control (28.9 q ha-1), respectively. Seed yield is ultimate output of a crop around which all other factors revealed. The seed yield was significantly affected by priming duration. Seed priming with H_2O significantly increased the seed yield in comparison with other treatment. The improved yield of primed seed plots may be due to early and improved emergence, more pods per plant or heavy seed produced in the priming treatments. That finally increased total yield. Similar reasons were reported by Harris *et al.* (1999) [8].

The interaction effect between 2%foliar application of urea and seed priming duration on straw yield (kg ha^{-1}) of soybean was found to be a non-significant. The straw yield was observed significantly higher with treatment of 2% foliar application of urea (56.0 q ha^{-1}) than other treatments. The straw yield was observed with application of control (44.7 q ha^{-1}). The straw yield is an important parameter of the biological yield to evaluate its productivity index and harvest index for judging the ultimate performance of a crop. The increase in straw yield is directly related mainly to increase in the vegetative growth of the plant. Application 2% foliar application of urea at pod initiation produced highest straw yield. The result of the study is in agreement with the finding of Alam *et al.* (2010) [1] who obtained the highest straw yield (6.06 t ha^{-1}) from 4-times foliar application of 3% urea solution by and the lowest straw yield (5.41 t ha^{-1}) was observed from 4 times foliar application of 1% urea solution. The straw yield was observed significantly higher with application of seed priming at 9hr (54.5 q ha^{-1}) than other treatments. but it was statistically at par with the application of seed priming at 6hr (52.4 q ha^{-1}). The straw yield was observed with application of control (45.3 q ha^{-1}) respectively. Straw yield is directly affected by growth parameters. The data regarding straw yield exhibited that significantly higher straw yield was recorded. These results are in agreement with those obtained by Chhipa *et al.* (1993) [4], who reported an increase straw yield for priming as compared with no soaking. These results endorse the findings of Rashid *et al.* (2000) [14], who reported that priming treatment significantly increased total biomass and dry weight as compared with the control.

The interaction effect between 2%foliar application of urea and seed priming duration on biological yield (q ha^{-1}) of soybean was found to be a non- significant. The biological yield was observed significantly higher with application of 2% foliar application of urea (87.0 q ha^{-1}) than other treatments. The biological yield weight was observed with application of control (73.7 q ha^{-1}). It was closely followed by one spray of 2% urea at flower initiation stage (1236 kg ha^{-1}) which recorded the highest number of pod spray of urea (1109 kg ha^{-1}). These results established the positive effect of supplying legume plants with supplementary nitrogen to have beneficial effects on enhancing growth and increasing seed yield. Similar observations were also reported by Attia and El-Dsouky (2001) [2]. Biological yield is major contributor total output of any crop and depends upon species, growing season and various other factors. The biological yield was observed significantly higher with application of seed priming at 9hr (85.6 q ha^{-1}) than other treatments but it was statistically at par with the application of seed priming at 6hr (82.7 q ha^{-1}). The lowest biological yield was observed with application of control (74.3 q ha^{-1}) respectively. The data indicated that seed priming significantly affected biological yield of soybean. Seed primed in H_2O produced the highest biological yield (13.1 ton ha^{-1}) followed by seed primed in KH_2PO_4 (12.3 ton ha^{-1}). The minimum biological yield (10.2 ton ha^{-1}) was produced by control treatment. The increase in biological yield might be due to better early seedling growth and plant nutrition as reported by Zhang *et al.* (1998) [20].

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