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# Yield and Yield Attributes of Soybean (*Glycine max* L.) as affected by Seed Priming

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

The field experiment was conducted to study the effects of different priming treatments on yield and yield attributing characters of soybean crop (SL-958). The seed priming treatments comprised of twelve priming treatments i.e. control or non-primed seeds, hydro or water primed seeds, seeds treated with solution of $KNO_3$ (0.5 and 1.0 %), $KH_2PO_4$ (0.5 and 1.0 %), KCl (50 and 100 ppm), $GA_3$ (50 and 100 ppm) and cytokinin (50 and 100 ppm) for 2 hour priming duration. Results revealed that yield attribute like number of pods per plant was recorded significantly higher with treatment 100 ppm $GA_3$ whereas other yield attribute like seeds per pod and 100- seed weight recorded non-significant results with different priming treatments. The pooled seed yield shows increase by 30.6 % with 100 ppm $GA_3$ than control.

## Introduction

Poor crop establishment is the main constraint in the growth and production of soybean and high yields can be associated with early vigour. Unfavourable environmental conditions are the major cause of poor seed establishment and low crop yield. However rapid germination of seedlings could emerge and produce deep roots before the upper layers of the soil are dried and crusted, which may result better crop establishment and higher crop yield (Ashraf *et al.,* 2005). In northern India, soybean is sown in first fortnight of June when the soil temperature is at its maximum and rainfall is also occurring in this season. So after rainfall the soil conditions became unfit for soybean emergence and cause rotting of seeds inside the soil due to high temperature of soil. One way for achieving good crop stand, enhancing capacity of legumes to fix more atmospheric nitrogen and getting more benefit from low fertile soils is seed priming which is a technique in which germination processes begin but radicle emergence does not occur.

The concept of seed priming was proposed by Hedecker in 1973. It is a basic and ease hydration process in seeds in which seeds are partially hydrated to a point where its pre-metabolic activities has started to begin without actual germination of the seeds. Seed priming found effective for pulses that is yields of crops were increased considerably by priming seeds before sowing (Musa *et al.,* 2001, Rashid *et al.,* 2004 and Harris *et al.*, 2004). In addition to better establishment, primed crops grew more vigorously, flowered earlier and yielded higher (Farooq *et al.*, 2008). It has also been reported that seed priming improves emergence, stand establishment, tillering, allometry, grain and straw yields, and harvest index.

## Materials and Methods

This study was conducted at the Punjab Agricultural University, Ludhiana ($30^o$ 56' N, $75^o$ 48' E and 247 m above mean sea level), Punjab during 2015-2016. Seeds of soybean variety SL-958 were used for seed priming treatments. Solution of $KNO_3$ (0.5 and 1.0 %), $KH_2PO_4$ (0.5 and 1.0 %), KCl (50 and 100 ppm), $GA_3$ (50 and 100 ppm) and cytokinin (50 and 100 ppm) and hydro-priming (priming with water) were used for priming treatment. Un-primed seeds were used as control. In all the priming treatments, seeds were primed for 2 hours priming duration. After priming, the seeds were dried under shade and immediately used for sowing. The field research trial consisted of twelve priming treatments and conducted in Randomized complete block design with four replications. The crop was sown on raised bed with 2 rows per bed with spacing of 67.5 cm. The recommended fertilizer dose of 32 kg N and 80 kg $P_2O_5$ $ha^{-1}$ was applied as urea (46 % N) and single superphosphate (16% $P_2O_5$) before sowing soybean. Stomp 30 EC (pendimethalin) at 1.5 litres $ha^{-1}$ was applied as pre-emergence, followed by one hand weeding at 40 days after sowing to control weeds.

Using five selected plants from each plot, number of pods per plant, number of seeds per pod, and 100- seeds were recorded. Before threshing the total weight of harvested crop plants from the net plot area was considered as the biological yield. The recorded biological yield was expressed in kg $ha^{-1}$. After sun drying for a few days, the harvested crop from respective net plot was threshed with thresher. Seed yield was recorded and expressed as kg $ha^{-1}$. The straw yield was obtained after deducting the seed yield from the total above ground biological yield (bundle weight before threshing) for each plot. HI was calculated by dividing economic (seed) yield by the total biological (seed + straw) yield and expressed as percentage.

$$HI\ (\%) = \frac{\text{Economic yield}}{\text{Biological yield}}$$

## Results and Discussion

### Yield attributes

### Number of pods per plant

Number of pods per plant is an important attribute which is highly co-related to the final seed yield. The higher the number of pods, the higher will be the yield. The data regarding the number of pods per plant are presented in Table 1. The number of pods per plant was found to be significantly influenced by priming treatments during both the years. In 2015, number of pods per plant was significantly higher with 100 ppm $GA_3$ treated seeds i.e. 73.9 pods per plant as compared to other treatments. Treatment 100 ppm cytokinin recorded significantly higher pod number per plant (67.6 pods per plant) which was statistically similar in results with 50 ppm $GA_3$ (65.4 pods per plant) and 50 ppm cytokinin i.e. 64.9 pods per plant, respectively. During 2016, similar trend was observed significantly higher number of pods per plant was recorded with 100 ppm $GA_3$ treated seeds (78.1 pods per plant). Other treatments like 100 ppm cytokinin recorded statistically similar results with 50 ppm $GA_3$

and 50 ppm cytokinin. When 100 ppm $GA_3$ was used to treat seed it recorded increase in number of seeds by 7.2 % than 100 ppm cytokinin treated seeds. This increase in number of pods per plant which might be due to more dry matter accumulation and LAI of the crop which increased the photosynthetic efficiency and assimilates production for pods per plant. Significantly 45 and 43 % increase in pods per plant was recorded when the soybean seeds were treated with 100 ppm $GA_3$ than control (50.9 and 54.4) in both the two years. Mazed *et al.,* (2015) also reported that Seed priming with $GA_3$ exhibited significant differences with respect of number of pods per plant.

## Number of seeds per pod

Number of seeds per pod is an important yield attributing character that influences the final seed yield. More number of seeds per pod will result in more number of total seeds per plant.

The number of seeds per pod did not differ significantly with different priming treatments (Table 1). During 2015, maximum number of seeds per pod was recorded with 100 ppm $GA_3$ treated seeds (2.60 seeds per pod). Other treatments 100 ppm cytokinin (2.35 seeds per pod), 50 ppm $GA_3$ (2.30 seeds per pod) and 50 ppm cytokinin (2.30 seeds per pod) also recorded comparative higher number of seeds per pod than control.

In 2016, the data recorded on seeds per pod shows that comparative higher number of seeds per pod was recorded with 100 ppm $GA_3$ i.e. 2.65 seeds per pod as compared to control. $GA_3$ treated seeds (100 ppm) recorded 10.6 and 10.4 % increase in seeds number per pod than 100 ppm cytokinin treated seeds in both the years. Mazed *et al.,* (2015) observed that Number of seeds per pod of chickpea differed significantly due to seed priming with $GA_3$.

## 100-seed weight

100 seed weight of a crop is positively correlated with final seed. It is evident from the data (Table 1) that different priming treatments had a non-significant effect on 100 seed weight in 2015 and 2016 respectively. Data showed that in 2015, 11.8 g weight of 100 seeds was recorded with 100 ppm $GA_3$ treated seeds which were comparative higher than other treatments. Same as during 2016, comparative higher 100 seed weight was recorded i.e. 10.9 g with treatment $GA_3$ at 100 ppm. In the year, 42 and 35 % increase in 100 seeds weight was recorded when the seeds were pre-soaked with 100 ppm $GA_3$ than control which recorded 8.27 and 8.05 g seed weight in 2015 and 2016, respectively.

## Biological yield

The data on biological yield as presented in Table 2 and Figure 1 shows that biological yield was significantly higher in $GA_3$ treated seeds @ 100 ppm in both the two years (5886 and 6014 kg $ha^{-1}$) which was statistically similar with 100 ppm Cytokinin (5732 and 5839 kg $ha^{-1}$) but significantly better than other treatments during the two years, respectively.

In 2015, when the seeds primed with $GA_3$ and Cytokinin at the rate of 50 ppm recorded statistically similar result with each other and recorded 5631 and 5632 kg $ha^{-1}$ biological yield respectively. In 2016, treatments viz. 50 ppm $GA_3$, 50 ppm cytokinin, 50 ppm KCl, 100 ppm KCl and 0.1 % $KH_2PO_4$ recorded statistically similar with each other. Cytokinin applied at 50 ppm recorded 15.6 % higher biological yield as compared to control in 2016. When dry seeds were used as control significantly lower biological yield was recorded during both the years (4935 and 4932 kg $ha^{-1}$) respectively. This increase in biological yield with respect to priming treatments might be due to more plant height and dry matter accumulation by the soybean crop. Mazed *et al.*, (2015) found similar results with different concentrations of $GA_3$. Seed priming with $GA_3$ recorded significant results in production of biological yield of chickpea crop. The highest biological yield was obtained (4388 kg $ha^{-1}$) when the seeds were pre-soaked in 225 ppm $GA_3$, which statistically similar (4132 kg $ha^{-1}$) to 300 ppm $GA_3$. The lowest biological yield (2503 Kg $ha^{-1}$) was found in hydro-primed chickpea seeds.

## Seed yield

Seed yield is an important parameter for judging the efficiency of the applied treatments. Seed yield, though a varietal characteristic yet, is altered through management of many agronomic practices. It is determined by various physiological processes at plant level such as dry matter accumulation, leaf area development, photosynthesis and translocation. Growth regulators are known to significantly affect the physiological processes which determine the final crop yield. The analysis of field observation presented in Table 2 and Figure 2, showed that significantly higher seed yield was recorded in both the years when the seeds were pre-soaked in $GA_3$ at 100 ppm. During 2015, significantly higher seed yield was recorded with treatment 100 ppm $GA_3$ i.e. 2442 kg $ha^{-1}$ which was statistically similar with other treatment 100 ppm cytokinin (2374 kg $ha^{-1}$), 50 ppm $GA_3$ (2329 kg $ha^{-1}$) and 50 ppm cytokinin (2329 kg $ha^{-1}$), respectively. Statistically at par seed yield was recorded when the seeds were treated with 50 and 100 ppm KCl (2248 and 2250 kg $ha^{-1}$), 0.5 and 1.0 % $KH_2PO_4$ (2224 and 2239 kg $ha^{-1}$), 0.5 and 1.0 % $KNO_3$ (2138 and 2192 kg $ha^{-1}$) and water treated seeds (2122 kg $ha^{-1}$) as compared to control.

**Table.1** Effect of seed priming on yield attributes of bed planted soybean

| Seed priming | Pods plant$^{-1}$ | | Seeds pod$^{-1}$ | | 100-seed weight (g) | |
|---|---|---|---|---|---|---|
| | 2015 | 2016 | 2015 | 2016 | 2015 | 2016 |
| Control | 50.9 | 54.4 | 2.02 | 2.12 | 8.27 | 8.05 |
| Water | 53.7 | 57.6 | 2.12 | 2.15 | 8.37 | 8.47 |
| $KNO_3$ (0.5 %) | 54.6 | 58.7 | 2.15 | 2.25 | 8.50 | 8.60 |
| $KNO_3$ (1.0 %) | 55.3 | 60.5 | 2.12 | 2.25 | 9.00 | 8.85 |
| $KH_2PO_4$ (0.5 %) | 55.8 | 61.3 | 2.20 | 2.20 | 9.20 | 8.92 |
| $KH_2PO_4$ (1.0 %) | 56.2 | 62.2 | 2.20 | 2.25 | 9.27 | 9.12 |
| KCl(50 ppm) | 56.5 | 63.1 | 2.25 | 2.25 | 9.27 | 8.95 |
| KCl(100 ppm) | 59.8 | 64.9 | 2.25 | 2.30 | 9.37 | 9.07 |
| $GA_3$ (50 ppm) | 65.4 | 72.1 | 2.30 | 2.40 | 10.3 | 9.80 |
| $GA_3$ (100 ppm) | 73.9 | 78.1 | 2.60 | 2.65 | 11.8 | 10.9 |
| Cytokinin (50 ppm) | 64.9 | 70.2 | 2.30 | 2.35 | 9.90 | 9.07 |
| Cytokinin (100 ppm) | 67.6 | 72.8 | 2.35 | 2.40 | 10.1 | 10.3 |
| CD (p=0.05) | 5.79 | 5.04 | NS | NS | NS | NS |

**Table.2** Effect of seed priming on yield and harvest index of bed planted soybean

| Seed priming | Biological yield (kg ha$^{-1}$) | | Seed yield (kg ha$^{-1}$) | | Pooled seed yield | Straw yield (kg ha$^{-1}$) | | Harvest index (%) | |
|---|---|---|---|---|---|---|---|---|---|
| | 2015 | 2016 | 2015 | 2016 | | 2015 | 2016 | 2015 | 2016 |
| Control | 4935 | 4932 | 1891 | 1908 | 1899 | 3044 | 3024 | 38.3 | 38.9 |
| Water | 5196 | 5162 | 2122 | 2116 | 2119 | 3074 | 3046 | 40.8 | 41.0 |
| $KNO_3$ (0.5 %) | 5233 | 5248 | 2138 | 2159 | 2148 | 3095 | 3089 | 40.9 | 41.1 |
| $KNO_3$ (1.0 %) | 5354 | 5284 | 2192 | 2176 | 2184 | 3162 | 3108 | 41.0 | 41.2 |
| $KH_2PO_4$ (0.5 %) | 5426 | 5399 | 2224 | 2212 | 2217 | 3202 | 3187 | 41.0 | 41.0 |
| $KH_2PO_4$ (1.0 %) | 5448 | 5487 | 2239 | 2251 | 2245 | 3209 | 3236 | 41.1 | 41.0 |
| KCl (50 ppm) | 5469 | 5501 | 2248 | 2275 | 2261 | 3220 | 3225 | 41.1 | 41.4 |
| KCl (100 ppm) | 5469 | 5613 | 2250 | 2320 | 2285 | 3219 | 3293 | 41.2 | 41.3 |
| $GA_3$ (50 ppm) | 5631 | 5701 | 2329 | 2370 | 2349 | 3302 | 3331 | 41.4 | 41.6 |
| $GA_3$ (100 ppm) | 5886 | 6014 | 2442 | 2521 | 2481 | 3444 | 3493 | 41.5 | 42.0 |
| Cytokinin (50 ppm) | 5632 | 5705 | 2329 | 2373 | 2350 | 3303 | 3332 | 41.4 | 41.6 |
| Cytokinin (100 ppm) | 5732 | 5839 | 2374 | 2445 | 2409 | 3358 | 3393 | 41.4 | 41.9 |
| CD (p=0.05) | 160 | 235 | 149 | 160 | 113 | 226 | 287 | NS | NS |

**Fig.1** Effect of seed priming on Biological yield (kg ha$^{-1}$) of bed planted soybean

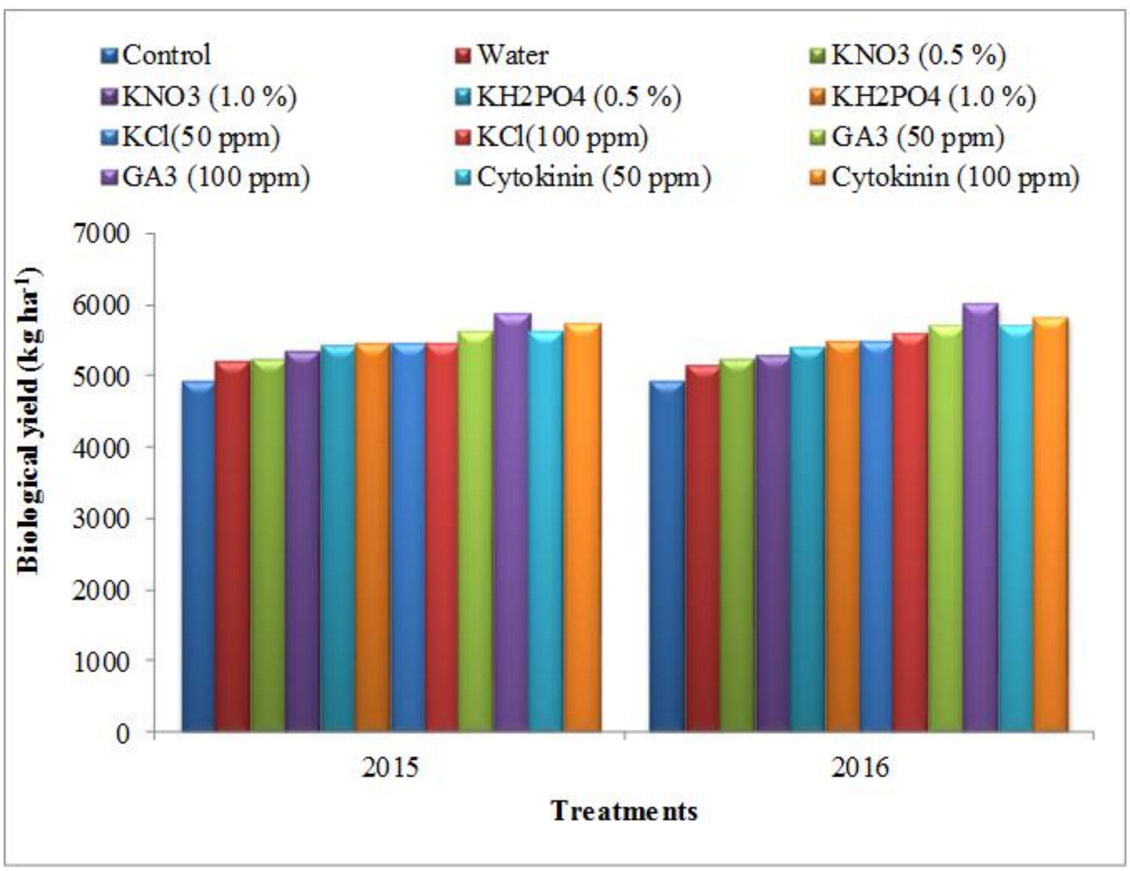


**Fig.2** Effect of seed priming on seed yield (kg $ha^{-1}$) of bed planted soybean

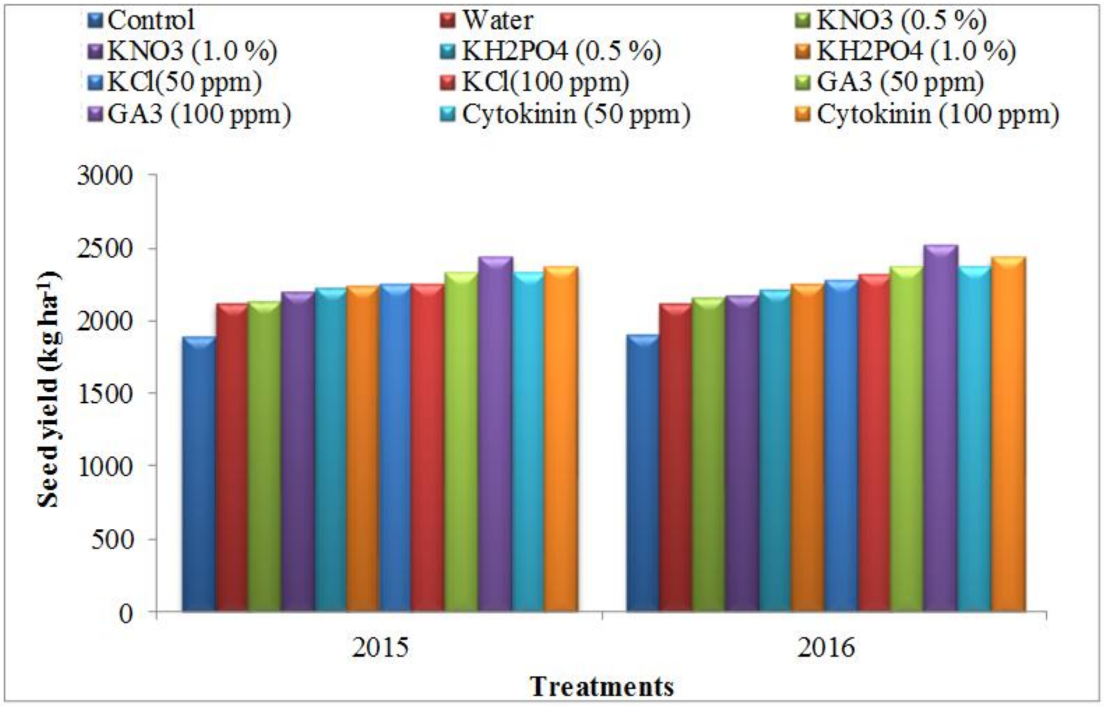



**Fig.3** Effect of seed priming on straw yield (kg $ha^{-1}$) of bed planted soybean

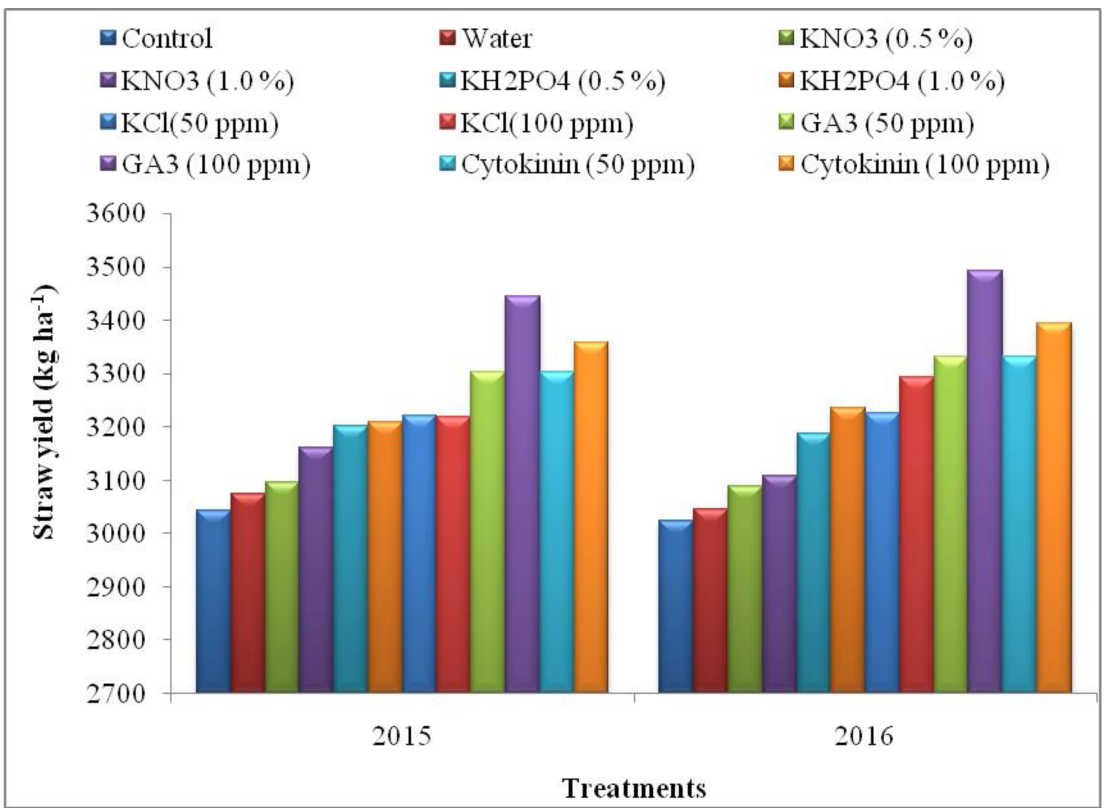
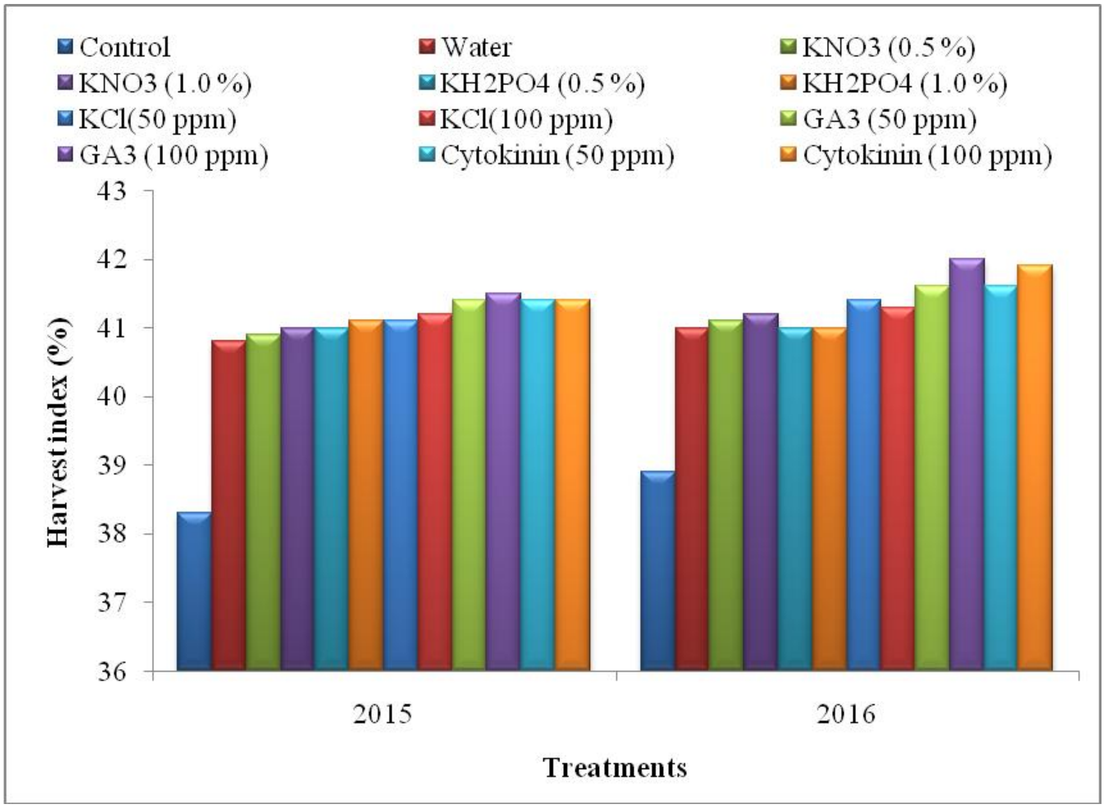


**Fig.4** Effect of seed priming on harvest index (%) of bed planted soybean




During 2016, when the seeds were treated with 100 ppm $GA_3$ it recorded 32.1 % higher seed yield as compared to control and recorded statistically at par results with 100 ppm cytokinin (2445 kg $ha^{-1}$), 50 ppm $GA_3$ (2370 kg $ha^{-1}$) and 50 ppm cytokinin (2373 kg $ha^{-1}$), respectively. Other treatment in which seeds treated with 50 and 100 ppm KCl recorded 2275 and 2320 kg $ha^{-1}$ seed yield which was statistically similar with 0.5 and 1.0 % $KH_2PO_4$ i.e. 2212 and 2251 kg $ha^{-1}$) and 1.0 % $KNO_3$ (2176 kg $ha^{-1}$) as compared to control and water treated seeds.

When seeds were primed with 100 ppm $GA_3$ it recorded 2.8 % and 3.1% higher seed yield as compared to 100 ppm cytokinin in both the two years. Maximum seed yield in $GA_3$ was registered due to higher number of pods per plant, more seeds per pod and 100 seed weight. This increase in yield attributing characters and final seed yield with $GA_3$ might be due to enhanced enzymatic action. Enzymes such as amylases, proteases and lipases play vital roles in the early growth and development of embryo. Any increase in the activity of these enzymes may result in early vigorous growth and good crop establishment which in turn improve the yield of the crop. Khan *et al.*, (2002) also reported that $GA_3$ improved the seed yield by the efficient exploitation of photosynthates and metabolic enhancement. Mazed *et al.*, (2015) found that when chickpea was primed with 225 ppm $GA_3$, it recorded significantly maximum seed yield.

Pooled analysis of seed yield is presented in Table 2. The data shows that significantly higher seed yield was recorded with treatment of 100 ppm $GA_3$ (2481 kg $ha^{-1}$) as compared to other which recorded statistically at par result with 100 ppm Cytokinin (2409 kg $ha^{-1}$). 100 ppm $GA_3$ recorded increase in seed yield by 30.6 % as compared to control. Same as 100 ppm cytokinin treatment recorded 26.8 % increase in seed yield than control.

## Straw Yield

Straw yield is directly affected by growth parameters. The data regarding straw yield exhibited that significantly higher straw yield was recorded when the soybean seeds were treated with 100 ppm $GA_3$ during both the years (Table 2 and Figure 3). In 2015, significantly higher straw yield was recorded with 100 ppm $GA_3$ (3444 kg $ha^{-1}$) which recorded statistically similar results with cytokinin @ 100 ppm (3358 kg $ha^{-1}$), 50 ppm cytokinin (3303 kg $ha^{-1}$), $GA_3$ at 50 ppm (3302 kg $ha^{-1}$) and 100 ppm KCl (3219 kg $ha^{-1}$). When seeds were treated with 100 ppm $GA_3$, straw yield was improved to the terms of 2.56 % as compared to 100 ppm cytokinin.

Similar trend was observed in 2016, significantly higher straw yield was obtained when the seeds were pre-soaked with 100 ppm $GA_3$ (3493 kg $ha^{-1}$) which was at statistically at par with cytokinin @ 100 ppm (3393 kg $ha^{-1}$), 50 ppm cytokinin (3332 kg $ha^{-1}$), $GA_3$ at 50 ppm (3331 kg $ha^{-1}$), 50 ppm KCl (3225 kg $ha^{-1}$), 100 ppm KCl (3293 kg $ha^{-1}$) and 1.0 % $KH_2PO_4$ (3236 kg $ha^{-1}$).

Control treatment i.e. dry seeds recorded lower straw yield during both the years i.e. 3044 and 3024 kg $ha^{-1}$, respectively. 100 ppm $GA_3$ recorded a significant increase of 13.1 and 15.5% in straw yield as compared to control or dry seeds during the two years of field study, respectively. Considerable increase in straw yield might be attributed to improvement in growth parameters like plant height, dry matter and LAI. Mazed *et al.*, (2015) reported that highest straw yield (2701 kg $ha^{-1}$) was observed with 225 ppm $GA_3$, whereas the lowest straw yield (1522 kg $ha^{-1}$) was found in 300 ppm $GA_3$.

## Harvest index

Harvest index (HI) is the measure of partitioning efficiency of biomass to the economic part of the crop i.e. seed yield in soybean. The data pertaining to HI are presented in Table 2 and Figure 4. Seed priming recorded non-significant effect on HI of the soybean crop in both the two years. Data presented in the table shows that 41.5 % HI was recorded when seeds were treated with 100 ppm $GA_3$ which was comparative better in result as compared to other treatments.

During 2016, a non-significant result was observed with different seed priming treatments. Results shows that seeds treated with 100 ppm $GA_3$ recorded 42.0 % HI which was comparative higher than other treatments. Control treatment or dry seeds recorded lesser values of HI i.e. 38.3 and 38.9 % during 2015 and 2016, respectively. $GA_3$ treated seeds at 100 ppm recorded increase in HI by 8.3 and 7.9 % as compared to control treatment during both the two years. Mazed *et al.*, (2015) observed that when chickpea seeds were treated with 225 ppm $GA_3$ it recorded significantly utmost harvest index than 75, 150 and 300 ppm $GA_3$. From this field study we can concluded that seed priming provide better good stand establishment under a wide range of environmental conditions. Results revealed that seed priming with 100 ppm $GA_3$ provide significantly higher yield and yield related attributes as compared to other seed priming treatments.

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