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Impact of planting date and row spacing on growth, yield and quality of Soybean; A Review

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Abstract

Soybean [*Glycine max* (L.) Merrill] is recognized as the "Golden bean" of the 21st century. The global rising demand of soybean is owing to its inimitable composition, outstanding dietetic value and health benefits. However, soybean grain yield is extremely less than regarding its yield potential. Main factors that reduce its yield are climate unevenness, inappropriate growing time, lower germination percentage, meager quality, scarcity of seed irrigation, improper planting space and weeds. Suitable planting date of soybean is probably most conspicuous cultural practice for maximizing seed yield. Line spacing is one of the major parameter that eventually affects nutrients uptake, growth and capitulate of plant. Keeping in above the above situation present is designed to evaluate the best planting date and row spacing for improving production.

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Introduction

Soybean [*Glycine max* (L.) Merrill] is recognized as the "Golden bean" of the 21st century (Khubele, 2015). The seed of soybean comprehends nearly 20% of the oil and 40 to 42% of protein (Dornbos & Mullen, 1992) and every one of the vital amino acids predominantly tryptophan, glycine and lysine. Soybean in addition to having a very good nutritive significance is proficient for fixing atmospheric nitrogen with symbiosis of *Rhizobium japonicum* microorganism. It also increases soil fertility and yield efficiency by fixing huge quantity of nitrogen all the way through the root nodule and falling leaves. Soybean is principally utilized for oil extraction and is currently well thought-out as one of the most significant profitable crop of the planet (Khubele, 2015). The cake left after oil extraction is still much rich in protein and thus, provides range for complementary protein dietary prerequisite for humans and domestic animals. Soybean comes at the second number at most traded edible oils in the global market following palm oil. It is used in various forms like soy flour, soy milk, soy butter, soy sauce, soy coffee, etc. (Endres *et al.*, 2001). It can be used as industrial produce like cosmetics, paints, soap or detergents, printing inks, plastic and rubber industry. Soybean is also extensively utilized in the industrialized production of diverse antibiotics.

World stipulate of soybean has augmented spectacularly with mounting uses in food products and livestock feed (Trostle, 2010). It has turn out to be progressively significant agricultural article of trade, with a sturdy increase in international annual production. The global rising demand of soybean is owing to its inimitable composition, outstanding dietetic value, health benefits and adaptability to diverse types of soils and climates and versatile end uses. Soybean grain yield is extremely less than regarding its yield potential. The lack of knowledge is the main cause of lower yield. Soybean production at farm level is restrained by numerous factors. Main factors that reduce its yield are climate unevenness, inappropriate growing time, lower germination percentage, meager quality and scarcity of seed irrigation (Rehman *et al.*, 2014). This gap can be over passed by utilizing optimum sowing date and proper row spacing. Vital factors for achieving elevated yield levels are rapid germination and smooth crop stands (Yari *et al.*, 2015). Due to negligible local production of soybean, importation of soybean as soy meal and soy oil has become essential to meet up the necessity of the country. Its cultivation remained inadequate to a low acreage and showed a decreasing trend when efforts were not made for its betterment.

Optimal planting date and row spacing are the most significant cultural decisions a farmer makes (Board and Kahlon, 2013). Analyses of crop growth dynamics and yield components have given a wide-ranging picture of how sowing date and lines pacing impinge on soybean production (Lobell *et al.*, 2009). Loomis and Connor (1992) stated that growth energetic parameters are light interception, LAI and rate and level of TDM. Some others that develop yield of soybean and all crops are, CGR and DM producing parameters like HI [(yield dry matter per area/total dry matter per area) x 100]. Seed counting per area, seed mass (grams per seed), number of pods per area, number of seeds per pod, number of pods per reproductive node and total reproductive nodes per area are the yield gears which have potential to manipulate soybean yield. Non-optimal sowing date and row spacing minimize seed yield by declining the number of seeds and number of seeds per area (Kahlon and Board, 2012).

Line spacing is one of the major parameter that eventually affects nutrients uptake, growth and capitulate of plant. Total plant population reduces by increasing the spacing but additional nourishment gives better individual plant stand and extra yield. Increasing or decreasing row spacing and plant populace have clear-cut effect on yield. In these concurrent divergent influences of the two constituents there should be a spot where maximum yield is predictable and that should be at the optimum plant spacing. Delay in planting causes plantlets to face with frost injury prior to crop maturity at the end of the season. Usually, planting time differs that depends on the meteorological circumstances of the area and the variety to be grown. The preceding studies illustrated that sowing before or after the optimum date considerably decreased the crop yield of soybean (Rehan, 2002). Calvino *et al.* (2003) stated that planting date has a major consequence on yield of the crop. Sowing date is an excellent loom to augment both yield and monetary profit if administration is done perfectly.

Crop features linked to the radiation capture and resource portioning of the crop are influenced by ecological conditions coupled with delayed sowing. From these, lower vegetative growth, shorter stems, lesser reproductive nodes and shortening of the reproductive phases are the main features (Kantolic and Slafer, 2001). In spring planted soybean, grain yield has less nutrients and more water deduction if flowering and grain filling are delayed and the number of grains is the chief yield element concerned in this regard (Calvino and Sadras, 1999). Egli and Bruening (2000) observed that by late planting reproductive growth faces less encouraging circumstances like short days and poorer temperature and radiation. Egli and Bruening (1992) stated that crop yield is condensed by lowering the temperature and radiation accompanying with delayed sowing in well-moisture soybean crops that resulted in late maturity in delayed October or early November. Keeping in above the above situation present is designed to evaluate the best planting date and row spacing for improving production.

Impact of planting date on growth and yield of soybean

Suitable planting date of soybean is probably most conspicuous cultural practice for maximizing seed yield. There is no exact date of soybean sowing but it's sowing after harvesting of maize crop often observed as delayed sowing. Soybean growers that support this school of thought often argued as soybean late sowing more decreases corn yield proportionally as compared to soybean (Hoeft *et al.*, 2000). However, among all the techniques of increasing soybean yield, suitable planting date is the most important technique which must be known to farmers. Determining the suitable sowing date of soybean is the most important factor for achieving optimum seed yield. Suitable sowing date may vary with cropping system, variety, and environmental conditions. Sowing soybean before or after suitable sowing date exerts negative effects on grain yield and quality. Sowing date also affects photoperiodism which regulates time taken to commence flowering as well as time to continue growth and developmental phase (Berger-Doyle *et al.*, 2014). It sown in spring and autumn seasons. Spring season commences from the end of January to 2nd week of March and autumn season from May to last week of July. Soybean sown before this satiable duration mostly decreases grain yield due to unsuitable soil temperature which leads to poor seed germination and sowing after the suitable date may reduce yield due to failure in development.

Till the end of 19th century little research work on soybean was accomplished. However, research on soybean crop was sufficiently increased because of interest at land grant institutions (Hymowitz, 1990). Research carried out on soybean sowing dates revealed that soybean sowing in 1st week of May in the Midwest mostly produced more grain yield against delayed sowing (Lueschen *et al.*, 1992). Oplinger and Philbrook, (1992) also reported that soybean sowing after the May significantly reduced grain yield. Meanwhile, soybean cultivar with different growth habits like determinate and indeterminate show different response to the different sowing dates. Determinate cultivars yielded better in early May or early June sowing whereas maximum grain yield in indeterminate cultivars was observed early May sowing (Robinson *et al.*, 2009). Recent researches indicated similar results where soybean sown in the end of April showed more seed yield compared with early May sowing (Robinson *et al.*, 2009). Soybean sown in late April or early May still produce more grain yield than sowing in the end of May. Analysis of the grain yield data with respect to sowing dates unveiled that soybean late sowing showed considerable decrease in grain yield (Egli and Cornelius, 2009).

Early sowing of soybean mostly produced more grain yield as compared to delayed sowing due to positive effects on yield components. It has been noted that early sowing produced more number of nodes (Pedersen and Lauer, 2004), pods and consequently higher seed yield per unit area (Robinson *et al.,* 2009). Sometimes soybean partly compensate the late sowing by increasing grain weight (Robinson *et al.*, 2009), however, it does not occur all times (De Bruin and Pedersen, 2008). Grain yield produced from the sowing date also depends upon the cultivar chosen and weather conditions during the whole crop growth period (De Bruin and Pedersen 2008). Varieties which require longer growth period increased grain yield when these are early planted. Weather can exert main effect on grain yield irrespective of the sowing date; however, soybean early sowing can be more affected by environmental conditions inside the field. This effect is perhaps more evident in January against February because cold spells and rain make difficult conditions for machinery action and growth and emergence of soybean are hampered. Whereas, despite of more early sowing, delayed sowing after the mid-May in the Midwest can cause severe decrease in grain yield (De Bruin and Pedersen, 2008). Several studies reported that soybean late sowing did not show decline in grain yield (Oplinger and Philbrook, 1992), however, it has been reported that late sowing impose negative impact on seed yield (Lueschen *et al.,* 1992). The impact level of early planting is may be specific to cultivar season and sowing site (Lueschen *et al.,* 1992). Seed weight and seed numbersm^{-2} is the most significant yield determining soybean factors (Board *et al.,* 1999). Early studies reported that these components have compensatory effect on total grain production of soybean (Sadras, 2007). Little literature has been found regarding effect of sowing dates on changes of these yield components. Elmore, (1990); Anderson and Vasilas (1985) reported that late sowing reduced the pods plant^{-1}. Late planting enhances or reduces the seed weight as reported by various studies (De Bruin and Pedersen, 2008b). Soybean late sowing provides valuable information about restrictions of primary yield components (De Bruin *et al.,* 2008). Farmers avoid soybean sowing in the end of April because of possible risks of damp soil, cold and experience to diseases of seedlings that in coming years can minimize plant stands, plantlet health (Hamman *et al.,* 2002) and grain yield (Wrather *et al.,* 2003). Sowing into cool and damp soil delays emergence of the seed may boost imbibition injury and experience to frost in late spring (Meyer and Badaruddin, 2001).

Impact of row spacing on growth, yield and quality of soybean

Several experiments have been done to execute the consequence of different line spacing on soybean (Pedersen and Lauer, 2003). Most of the experiments made a consensus that soybean crop sown in narrow rows significantly increased seed yield. Maximum soybean grain yield has been reported where crop was sown in 25cm spacing compared to76cm spacing (Chauhan *et al.,* 2010). Same yield response was recorded where soybean was sown late under or no-till conditions (Oplinger and Philbrook, 1992). The most common row spacing for soybean cultivation is 19, 25, 38, 50, 76 and 100cm. Various experiments carried out on soybean row spacing concluded that narrow rows (less than 50cm) mostly gave additional grain yield compared to wider row spacing (greater than 50cm) under different crop growing conditions (Vonk, 2014). Wide row spacing possesses only charm that it creates ease in performing cultural practices. Wide rows ensure minimum crop damage during the application of post emergence herbicide. Few researchers reported that there was not yield response when soybean crop was sown in narrow rows (Pedersen and Lauer, 2003). Previous researchers reported that response of soybean yield under the narrow row spacing depends upon specific management practices and meteorological conditions of the experimental site.

Crop emerging season which receives poorer rainfall than optimum as well lowers the chances of optimum response of soybean grown in narrow rows (Holshouser and Whittaker, 2002). Soybean crop exposed to acute water shortage and sown in narrow rows produced lower seed yield compared with crop grown in wide spacing (Elmore, 1998). It happened probably due to quick development of canopy and high usage of water in narrow line spacing at the start of the period which resulted in minute amount of water available during critical phase of crop growth (Holshouser and Whittaker, 2002). Effects of row spacing are more pronounced on soybean grain yield when crop is sown after the recommended sowing date. Soybean late sowing in narrow rows however cannot recover yield but it reduces loss up to 16% (Weaver *et al.,* 1991). Further experiments indicated similar outcomes with narrow rows by providing yield advantage of 244 and 120 kg ha^{-1} compared to wide rows keeping the sowing dates constant. Same yield response has been reported from soybean varieties which mature early, when they are late sown. Early maturing soybean cultivars sown in narrow rows take yield advantage over wide rows (Sweeney *et al.,* 1995).

The reason of increased grain yield in narrow row spacing is still unknown. Board and Harville (1992) indicated that the increased sunlight interception was the possible reason of increased yield in narrow rows. Board *et al.* (1990) reported that at pod filling stage if soybean receives 95% light interception it showed remarkable increase in seed yield. It was documented that planting in narrow rows initiated rapid start of pod filling due to the lighter interception at pod filling stage (Taylor *et al.,* 1982). Experiment showed that soybean sown in wide rows possessed more number of pods but only 61% against narrow rows where soybean showed 90% pods. Ordinary soybean cultivation reported positive effects of uniform sowing on grain yield. Various researchers reported that this positive effect was due to uniform spacing (Andrade *et al.,* 2002), while others indicated it was the outcome of lesser plant competition (Egbe, 2010). Some specific experiments indicated that standard row spacing increases the effective utilization of carbohydrates by soybean (Vonk, 2014) and enhances initial growth which lead to the better crop stand and more productive plants to enhance grain yield (Sangoi *et al.,* 2001). Regardless of standard row spacing, researchers are in clash for pointing out the exact factor which is the source of increased soybean yield when planted in narrow spacings. Clifton-Brown *et al.* (2015) stated that seed production had not direct relation to TDM production, DM produced throughout the time of formation of seeds or intercepting light. Production of dry matter directly depends upon light interception. Soybean planting at standard rows mobilizes partitioning of photosynthate towards grain production regardless of vegetative production. Sangoi *et al.* (2001) provided the reason of the increased yield by equidistant sowing by stating that higher plant weight was main reason of increased grain yield while all other practices kept normal. Bullock *et al.* (1998) indicated that the higher plant size, because of improved early growth, produced supplementary productive nodes having more filled pods which lead to higher grain production.

Lot of study material has been found in literature regarding research done on wide and narrow rows sowing. Research indicated that soybean sowing in narrow rows provide chances to increase grain yield. However, narrow rows don't increase grain yield every time (Pedersen and Lauer, 2003). In lot of experiments it has been found that narrow rows mostly increased grain yield (De Bruin and Pedersen, 2008a). Seed yield is augmented by decrease in spacing to a definite point and reduces with decreasing the crop density (Board and Harville, 1992). Effect of narrow row spaces on rain yield depends upon crop stress, crop site and sowing date (Heatherly, 1988), so, increasing light interception and reducing rate of evaporation are the most important reasons to increase soybean grain yield. Relatively slower stem elongation has been found in those plants which receive more light. The ratio of red/far red light, has a crucial part in stem elongation (Franklin and Whitelam, 2005) and consequently on plant height. Paszkiewicz (1997) gathered data regarding row spacing and grain yield from different research stations and concluded that soybean sown in lesser than 56cm rows showed increase of 4% in seed yield compared with 76cm line spacing. Farnham (2001) documented that seed yield decreased about 2% by narrowing row spacing from 76 to 38cm.

However, Porter *et al.* (1997) exhibited more grain yield for narrow spacing compared with wider spacing. De Bruin and Pedersen (2008) stated that smaller increase in seed yield using narrow rows is because of more stem breakage.

In northern latitudes, some growers sow soybean in 38cm instead of 76cm rows due to continuous increase in seed yield at 43° N latitude (Lee, 2006). Soybean sowing at 19cm spacing through seed drill was most cost-effective in annual rotation of corn–soybean and had a 4.8% grain benefit by drilling as compared to 38cm spacing (Lambert and Lowenberg-DeBoer 2003). So, this is not obvious that if soybean should be sown at 38cm spacing through planter as a substitute of 19cm rows through seed drill in northern latitudes. Soybean planted at 19 and 76cm spacings showed 5% increase in grain yield in southern Wisconsin, 8.7% rise in central Wisconsin and 9.6% increase in northern Wisconsin in 3 years' research trials (Bertram and Pedersen, 2004). These experiments also showed that soybean sown at 19cm spacings produced grain yield statistically to 38cm spacing in northern and central Wisconsin and a decrease of 4.7% than 38cm spacing in southern Wisconsin. Farnham, (2001) noted that soybean sown in 17, 36, or 45cm apart rows produced 6 to 18% grain produce compared with 76cm spacing. Soybean sown at 25cm apart produced 21% and 8-14% more grain production compared with 76cm spacing, respectively Sangoi *et al.* (2001) stated that increased sunlight interception, grain yield, rapid canopy closure effectively reduces the growth of weed seedling, as against wide row spacing.

Conclusion

It is concluded from the above review that date indicates that under most conditions narrow-row spacings will reduce the likelihood of weed resurgence in soybean. In many studies, this response has been directly correlated with the faster rate of canopy closure and reduction in light interception at the soil surface in narrow- compared to wide-row systems. The available studies also indicate that the critical time of weed removal is most likely to occur later in narrow-compared to wide-row soybeans. Soybean sown in late April or early May still produce more grain yield than sowing in the end of May. Furthermore, narrow rows (less than 50cm) mostly gave additional grain yield compared to wider row spacing (greater than 50cm) under different crop growing conditions.

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