Weeds, photosynthetically active radiation interception, soil temperature, biological and seed yield of soybean as affected by planting methods and fertilizer rates

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ABSTRACT

A field experiment on soybean conducted in a split-plot design assigning planting methods in main plots and fertilizer rates in sub-plots at Punjab Agricultural University, Ludhiana during Kharif 2007–08 under irrigated conditions to determine the influence of planting methods and fertilizer rates on weeds, photosynthetically active radiation interception (PARI), soil temperature, biological and seed yield. Soil of the experimental field was loamy sand low in nitrogen and medium in phosphorus and potassium. The results revealed that highest seed yield (27.49 q ha⁻¹) of soybean was obtained under bed planting with mulch method (BPWM) which was significantly better to flat sown with mulch (FSWM), conventional tillage flat sown (CT) and zero tillage (ZT) except bed planting (BP). This increase in seed yield was due to higher biological yield, less weed infestation, more PARI and less soil temperature at early stage of crop. Different fertilizer levels did not significantly affect the seed yield of soybean. However, the maximum seed yield (24.0 q ha⁻¹) was recorded with F2 level of fertilizer followed by F1 (23.5 q ha⁻¹) and F3 (22.2 q ha⁻¹) level of fertilizer.

Keywords: Soybean, weeds, soil temperature, photosynthetical active radiation, planting methods.

Abbreviations: Photosynthetically active radiation interception, planting methods.

1. INTRODUCTION

Soybean [Glycine max (L.) Merrill] is an important grain legume believed to have originated in China. Soybean is rich in protein (40%), moderate in cholesterol free oil (20%) and appreciable amounts of minerals and vitamins (Chauhan et al., 1988). It accounts for 60% of the world supply of vegetable protein. Cereal are low in protein and deficient in lysine whereas soybean is rich in both protein and lysine. Its oil serves both as a source of edible oil and raw material for food and feed industry. Soybean is easily processed into various edible forms such as soy-flour, soy-sauce, soy-milk and milk based products and confectionary items. Soybean has the potential to bridge the widening gap between demand and supply of edible oil and protein. Its cultivation improves the soil health through biological nitrogen fixation. Being a legume it can fix approximately 125 - 150 kg N ha⁻¹ (Chandel et al. 1989). It also leaves residual nitrogen effect of 30 - 40 kg N ha⁻¹ for succeeding crop (Prasad 2005). Among several production factors fertilizer management and methods of planting are very crucial in obtaining the higher yields. It has moderate nutrient and water requirement and its yield is higher than other pulses and oilseeds. Soybean requires only a starter dose of nitrogen as it own biological nitrogen fixation plays a key role in the growth and yield of soybean. The judicious use of two sources of nitrogen viz. fertilizer nitrogen and biologically fixed nitrogen ensure better crop growth and yield. Phosphorus is another important nutrient that effects the growth and yield of soybean by playing an important role in the process of biological nitrogen fixation. Phosphorus maintains the high rhizobial population level in the soil. Hence phosphorus application in soybean increases the total biomass production resulting in enhanced yield. Soybean is a shy germinator. High temperature at the time of sowing may be one of the reasons for poor emergence.

PHOTOSYNTHETICALLY ACTIVE RADIATION

Photosynthetically active radiation (PAR), designates the spectral range (wave band) of solar radiation from 400 to 700 nanometers that photosynthetic organisms are able to use in the process of photosynthesis. This spectral region corresponds more or less with the range of light visible to the human eye. Photons at shorter wavelengths tend to be so energetic that they can be damaging to cells and tissues, but are mostly filtered out by the ozone layer in the stratosphere. Photons at longer wavelengths do not carry enough energy to allow photosynthesis to take place. Chlorophyll, the most abundant plant pigment, is most efficient in capturing red and blue light. Accessory pigments such as carotenes and xanthophylls harvest some green light and pass it on to the photosynthetic process, but enough of the green wavelengths are reflected to give leaves their characteristic color. An exception to the predominance of chlorophyll is autumn, when chlorophyll is degraded (because it contains N and Mg) but the accessory pigments are not (because they only contain C, H and O) and remain in the leaf producing red, yellow and orange leaves. Photosynthetic rate and related parameters can be measured non-destructively using a photosynthesis system, and these instruments measure PAR and sometimes control PAR at set intensities.

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and growth of this crop. Lowering the soil temperature at the sowing time by suitable planting techniques may help to improve germination and growth of this crop which ultimately results in optimum plant population, better aeration, optimum soil temperature, more leaf area index, and more light interception. Straw mulch is another factor that creates favourable environment which helps to promote the plant growth, increases water and nutrients uptake and thus more yield. Studies on sandy loam soil of Punjab showed that straw mulching lowered the maximum temperature and increased the minimum soil temperature in the soybean seed zone (Mehta and Prihar 1973).

2. MATERIALS AND METHODS

An experiment was conducted at Punjab Agricultural University, Ludhiana during the Kharif season of 2007-08 under irrigated conditions to determine the influence of nitrogen and phosphorus levels on soybean under different planting techniques. The experimental site was loamy sand, having pH 8.1, Electrical conductivity 0.44 dS m⁻¹, organic carbon 0.24 % and 183, 13.5 and 246.5 kg ha⁻¹ of available nitrogen, phosphorus and potassium, respectively. The field trial was conducted using variety SL 525 in a split-plot design with four replications comprising five planting methods i.e. bed planting (BP), bed planting with mulch (BPM), flat sown with mulch (FSWM), conventional tillage flat sown (CT) and zero tillage (ZT) were kept in main plots while three levels of fertilizer viz. N 15 kg ha⁻¹ + P₂O₅ 40 kg ha⁻¹, N 30 kg ha⁻¹ + P₂O₅ 60 kg ha⁻¹ and N 40 kg ha⁻¹ + P₂O₅ 80 kg ha⁻¹ in sub-plots with gross plot size of 11 m x 4 m and net plot size 10 m x 3 m. In case of zero tillage plots, soybean was sown without bed seed preparation after harvesting of wheat crop with the help of zero till drill. The experiment was conducted under irrigated condition. However, a pre-sowing irrigation (rauni) was given for better germination and sow on June 9, 2007. The different doses of fertilizer as per the treatment were applied as basal dose by broadcasting at the time of sowing. Crop was harvested November 12, 2007.

3. RESULTS AND DISCUSSION

The data in Table 1 showed that bed planting with mulch gave significantly higher biological yield as compared to bed planting, conventional flat sown with or without mulch and zero tillage method of planting. Similarly, bed planting also produced significantly more biological yield than flat sown, mulch sown and zero tillage methods, however, the lowest biological yield produced by zero tillage. Mulch application had shown significant increase in biological yield under bed planting methods than no mulch. This might be due to the moisture availability for longer period and due to less weed, weed dry matter (Table 1), more PAR (Table 1) and less soil temperature (Table 2) in the early stage of crop. The different levels of fertilizer had a non-significant effect on biological yield. The response to fertilizer levels to biological yield follows similar trend as it was in the case of seed yield.

Seed yield is an important criterion for comparing and judging the efficiency of different treatments. Seed yield is primarily an outcome of genetic constitution of the crop plant, which is controlled by nutritional, hormonal, environmental and other management factors. The responses in the yield are in fact the culmination of yield building process and the favorable and adverse effects experienced by the crop during different stages of crop growth. The data in the Table 1 revealed that different planting methods had significant influence on the seed yield of soybean. Highest seed yield was obtained under bed planting with mulch method of planting followed by bed planting, flat sown with mulch, flat sown without mulch and zero tillage. Bed planting with mulch, which was on par with bed planting without mulch and produced significantly higher seed yield as compared to all other methods of planting. Conventional flat sown was on par with flat sown with mulch and zero tillage methods of planting. However, numerically maximum seed yield was observed under flat sown mulch followed by flat sown and zero tillage methods of planting. Bed planting produced greater seed yields over the conventional methods of planting. Singh et al (1999), Raut et al (2000), and Kaur (2003) also reported that bed planting gave significantly higher biological yield than flat or conventional method of planting due to better aeration and more transfer of assimilate from source to sink which ultimately contributed towards higher seed yield in bed sown crop. Mulching with paddy straw showed a non-significant increase in seed yield both under conventional flat sown and bed planting methods. In case of fertilizer levels, there was a non-significant increase in the seed yield of soybean up to F2 level of fertilizer. Slightly higher seed yield at F2 level of fertilizer may be due to the combined effect of nitrogen, phosphorus and FYM which resulted in higher biological yield. Jayapal and Ganesraja (1990) and Kang et al (1995) also reported increase in grain yield due to application of starter dose of nitrogen (80 kg/ha). Singh (1995) observed significant reduction in the grain yield with the application of 80 kg P₂O₅ ha⁻¹.

Nature and density of weed flora is an important component of production. The effects of different planting methods and fertilizer levels on weed count at 35 DAS before hoeing are presented in Table 1. The predominant weed flora was recorded as Commentina bengalensis (Kaon Makki), Cydnodon dactylon (Khabal ghas), Cyperus rotundus (Motha), Eleusine egypcticum (Madhana), Digera arvensis (Tanda), Errogasites pilosa (Love grass) and Trianthea portulacastrum (Itsi). Data presented in Table1 revealed that methods of planting influenced significantly the weed count. Weed count was significantly higher under zero tillage conditions than all other methods of planting. Similarly, conventional (flat sown) methods of planting had significantly higher number of weeds than bed planting treatments. The weed count was significantly reduced with the application of mulch over no mulch. A significant decline in weed count was recorded on loamy sand soil of Ludhiana in Punjab, when crop was mulched at 6t ha⁻¹ compared to check (Ralli 2001). Among different fertilizer levels, F3 level produced significantly higher number of weeds as compared to F2 and F1 level. But the weed count value was similar under F1 and F2 level of fertilizer.

Data revealed that the methods of planting and fertilizer levels had significant effect on dry matter accumulation of weeds (Table 1) Among different methods of planting, zero tillage recorded significantly higher dry weight of weeds as compared to flat sown, bed planting, flat sown with mulch and bed planting with mulch methods. Effect of mulching on dry matter accumulation of weeds was significant. However, the dry matter accumulation of weeds reduced significantly with the application of mulch in case of bed planting with mulch and conventional method with mulch. This might be due to lesser number of weeds with the use of mulch at 5t ha⁻¹. Similar results were reported by Williams et al (1998) who recorded reduction in weed biomass with the use of rye residue as mulch. Fertilizer levels had significant effect on dry weight of weeds. The highest dry weight of weeds was recorded at F3 level which was at par with F2 level of fertilizer. F1 level of fertilizer had produced significantly lower dry weight of weeds.
Maximum solar radiation was intercepted by bed planting with mulch treatment at all the growth stages followed by bed planting, flat sown with mulch, flat sown and zero tillage (Table 1). Bed planting intercepts higher solar radiation as compared to conventional flat sown with and without mulch and zero tillage treatments due to more leaf area index (data not given) under bed planting treatments. Application of mulch resulted in higher solar radiation interception at 50, 80 and 110 DAS under bed planting as compared to conventional flat sown treatments and zero tillage. Similar results were recorded by Kaur (2003). Zero tillage method of planting intercepted significantly lower photosynthetically active radiation as compared to all other treatments except at 80 DAS where it was at par with flat sown method. In case of different fertilizer levels Photosynthetically active radiation interception was significantly higher under F3 level of fertilizer followed by F2 and F1 levels at 50, 80 and 110 DAS. Photosynthetically active radiation interception at F3 levels was at par with F2 levels of fertilizer at all growth stages of crop.

Data in Table 2 clearly revealed that application of mulch helps to reduce the temperature during the initial stage of the crop. It helps in temperature conservation during cool night hours as well as lowering the soil temperature during day. The beneficial effect of mulch was visible in lowering the soil temperature by 2-3°C than without mulch. Application of mulch helped in providing favorable conditions for moisture conservation leading to increased emergence count (data not given) in bed sown as well as conventional flat sown plots as compared to un-mulched plots. Kaul and Sekhon (1975) also reported lowering of soil temperature and improved germination percentage of soybean with mulch application. Jalota and Panhar (1979) reported increased soil moisture storage with mulching while Sarmah et al. (1986) obtained higher seedling emergence values due to mulching.

**SUMMARY OF RESEARCH**

- Bed planting with mulch gave significantly higher biological yield as compared to bed planting, conventional flat sown with or without mulch and zero tillage method of planting. Similarly, bed planting also produced significantly more biological yield than flat sown with mulch, flat sown and zero tillage methods, however, the lowest biological yield produced by zero tillage.
- Highest seed yield was obtained under bed planting with mulch method of planting followed by bed planting, flat sown with mulch, flat sown without mulch and zero tillage. The different levels of fertilizer had a non-significant effect on biological yield and seed yield.
- Zero tillage recorded significantly higher dry weight of weeds as compared to flat sown, bed planting, flat sown with mulch and bed planting with mulch methods. The highest dry weight of weeds was recorded at F3 level which was at par with F2 level of fertilizer. F1 level of fertilizer had produced significantly lower dry weight of weeds.
- Maximum solar radiation was intercepted by bed planting with mulch treatment at all the growth stages followed by bed planting, flat sown with mulch, flat sown and zero tillage. Photosynthetically active radiation interception was significantly higher under F3 level of fertilizer followed by F2 and F1 levels at 50, 80 and 110 DAS. Photosynthetically active radiation interception at F3 levels was at par with F2 levels of fertilizer at all growth stages of crop.
- Application of mulch helps to reduce the temperature during the initial stage of the crop. Maximum net returns and benefit cost ratio was observed under bed planting with mulch method of planting. The magnitude of increase in the net return under bed planting with mulch was 6.97, 45.05, 59.55 and 64.12% as compared to bed planting, flat sown with mulch, flat sown and zero tillage, respectively. As far as the benefit cost ratio is concerned, zero tillage method resulted in slightly higher benefit cost ratio as compared to conventional flat sown with and without mulch. The reduction in net returns under conventional flat sown with or without mulch and zero tillage treatments was due to lower seed and biological yields of soybean because of wider spacing for sowing of crop as two rows require 90 cm space under these methods but in case of bed planting two rows are planted at 67.5 cm spacing.

**FUTURE ISSUES**

This study will help to enhance the adoption of soybean crop in those areas where it is not grown, using the bed planting with mulch to get the maximum productivity and higher net returns. It will also help for planning the research on soybean to produce more at less cost by cultivate with different methods of planting using less fertilizer.

**DISCLOSURE STATEMENT**

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