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Effect of sowing dates, mulching and seed rates on nutrient uptake and productivity of soybean in sub - humid Punjab, India

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ABSTRACT

A field experiment was conducted for three years to study the effect of sowing dates, mulching and seed rates on nutrient uptake and productivity of soybean under irrigated conditions in sub-humid Punjab on a silty clay loam soil which was low in available N, medium in available P and available K. The experiment was conducted in a split plot design with the combination of three sowing dates and mulch in main plots and three seed rates in sub-plots with three replications on fixed site. The results revealed that sowing on June 30 and mulching recorded the highest number of pods plant^{-1}.There was no significant influence of seed rates on yield attributes. Seed yield also remained at par under different sowing dates, mulching and seed rate treatments. Stover yield however, was significantly higher under the earlier sowing dates and mulching. Highest total N uptake was observed under June 30 sowing date whereas total P and K uptake was highest in May 20 sowing date. No significant effect of mulching was observed on total N and K uptake. Among seed rates maximum total N uptake was observed under 75 kg seed ha^{-1}. The results suggest that soybean performed better when sown with 60 kg seed rate ha^{-1} on June 30 and mulched with wheat straw.

Key words: Mulching, Seed rate, Sowing date, Soybean, Uptake.

INTRODUCTION

Soybean (*Glycine max* (L.) Merr.) is main source of protein (35-45 per cent) and edible oil (18-22 per cent) in the world (Javor *et al.*, 2001). It is a unique crop among the legumes because it provides complete protein containing 8 amino acids essential for human health (Asadi and Faraji, 2009) and is a concentrated source of isoflavones which have a potential role in preventing and treating cancer and osteoporosis. Soybean seed is an important source of K, Ca, Zn, Fe, B, and P. Its oil includes saturated fatty acids, such as palmitic (12–13% of total oil) and stearic (3–4%) and unsaturated fatty acids such as oleic (19–23%), linoleic (48–58%), and linolenic (5–8%). In Asian countries, soybean is made into various foods such as tofu, soymilk, bean sprouts, dried tofu, soy sauce, soy flour etc. Among grain legumes, soybean is an economically important crop that is grown in diverse environments throughout the world. Its cultivation also improves soil health because of its atmospheric nitrogen fixation capacity and deep root system.

Soybean is a facultative short-day plant and generally requires short day photoperiod for flowering. Photoperiod not only affects the phenological and physiological development of soybean but also affects its morphological structures. Indeed, the seed filling period and, therefore, the time to harvest maturity is also photoperiod sensitive. Being a subtropical legume, root zone temperature of 25-30^{O} C is optimum for both nodulation and efficient nodule functioning (Kaur *et al.*, 2015). Thus, among various agronomic practices, sowing date has more influence on seed yield of soybean than any other production practice. Appropriate sowing date causes optimal utilization of the climatic factors such as temperature, humidity, day length and also anthesis time adaptation with proper temperature (Hashemi, 2001). Early sowing in the season may encourage higher vegetative growth which may invite various diseases and insect pests, whereas delayed sowing may shrink the vegetative phase, which in turn reduces dry matter accumulation leading to poor partitioning to reproductive parts and ultimately poor realization of the potential yield. Moreover, the experimental site being located in the sub-mountain undulating plain region (foothills of shiwalik range), manipulation of the sowing dates can be very effective in enhancing yields of soybean under such agroclimatic situation.

Mulching is a common practice to cover soil surface and it not only conserves moisture but also moderates temperature besides effectively controlling the weeds. It creates congenial conditions for the growth and ameliorates various environmental stresses (Macilwain, 2004). It exerts decisive effects on earliness, yield and quality of the crop. Straw mulching has a major effect on soil water and thermal regimes. The mulch probably acts as an insulator, resulting in smaller fluctuations in soil temperature in mulched treatments as compared to without mulch. Mulches can be

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more effective under extreme weather conditions as compared to normal conditions.

Optimum seeding rate is also one of the most influential factors for increasing soybean profitability, as seed cost is one of the expensive inputs. The environment also exerts an influence on deciding the final seeding rate. Dry and hot conditions require fewer plants to maximize yields while favorable environments need higher seeding rates to capture the maximum yield potential. Also, soybean seeding recommendations and planting date are tied together. In the sub-humid areas of Punjab a large quanitity of mulch is available in the form of crop residues which otherwise creates disposal problem also. So the integration of all these agronomic practices may lead to realization of higher yield potential of the crop.

Keeping all this in view, this study was executed to investigate the interventions of sowing time, seeding rate and effectiveness of mulch on growth, nutrient uptake and yield of soybean under semi-arid sub tropical north India.

MATERIALS AND METHODS

A field experiment was conducted at the regional research farm of the Punjab Agricultural University, Langroya (Distt. SBS Nagar) for three years under irrigated conditions to study the effect of sowing dates, mulching and seeding rates on nutrient uptake and productivity of soybean. The soil of the experimental field was silty clay loam in texture, low in available N (138.0 kg/ha), medium in available P (22.2 kg/ ha) and available K (175.0 kg/ha) and alkaline in reaction (pH 8.31). Soybean variety SL 525 was sown for experimentation. The experiment was laid in split plot design with combination of sowing dates and mulch in main plots and seed rates in sub-plots with three replications on fixed site. The treatments consisted of three sowing dates *viz:* May 20, June 10 and June 30 and two mulch treatments viz: no mulch and mulching with wheat straw @ 6 t ha^{-1} and three seeding rates *viz*: 60, 75 and 90 kg seed ha^{-1}. Wheat straw mulch was applied @ 6 t ha^{-1} just after sowing of soybean under different sowing dates. Soybean crop received a uniform basal dose of 30 kg N ha^{-1} in the form of urea and 60 kg P_2O_5 ha^{-1} as single super phosphate along with 10 t FYM ha^{-1}. Stomp 30EC(pendimethalin) @ 1.5 l ha^{-1} as pre-emergence was applied to soybean for the control of weeds followed by one hand weeding 40 days after sowing. The crop was harvested at maturity under different dates of sowing. Entire dose of N, P and K were applied at the time of sowing to soybean. Soybean seeds were treated with *Bradyrhizobium japonicum.* Soybean was sown at a row spacing of 45 cm and the crop was irrigated as and when required. All the recommended cultural operations other than the treatments were practiced to raise the crop. To determine the uptake of NPK by soybean, plant samples of different treatments were collected for their analysis. Soil samples were collected from 0 to 15 cm layer, dried in shade and ground to pass through 2 mm sieve. Soil samples were then analysed for organic carbon (Walkley and Black, 1934), available N (Subbiah and Asija, 1956), available P (Olsen *et al.*, 1954) and available K (Merwin and Peech, 1950). At the time of harvest, grain and straw samples of soybean were collected from different treatments and oven-dried at a temperature of 70°C. The dried samples were ground in a stainless steel Willey mill. For the determination of N in soybean grain and straw, a known weight of grain and straw were digested in concentrated H_2SO_4 at 350°C and the digest was analysed for N by Kjeldahl distillation method. For the determination of P and K the grain and straw samples were digested at 150 °C in diacid mixture of $HClO_4$ and HNO_3 in the ratio of 3:1. The uptake of NPK by grain and straw was calculated by multiplying the NPK content with the respective oven dried grain and straw yield of soybean. The total NPK uptake was then calculated by summing the grain and straw uptake. The data were analysed in split plot design to determine the significance among different treatments.

RESULTS AND DISCUSSION

Growth characters and yield of soybean: There was progressive decrease in plant height with successive delay in sowing date from May 20 to June 30 (Table 1). In all the three years, early sowing on May 20 produced the tallest plants which was significantly higher than the crop sown on June 30. Moosavi *et al.* (2011) also reported a decrease in plant height with delay in sowing from May to June. Similar results have been reported by Salahi *et al.* (2006). The reduction of duration of period due to increased temperature with delayed sowing caused reduction in plant height (Heidarizadeh *et al.*, 2008). Number of branches $plant^{-1}$ was significantly reduced under delayed sowing on June 30 as compared with early sowing on May 20 and June 10. Effect of sowing dates on number of branches was not significant where as number of pods $plant^{-1}$ improved significantly with successive delay in sowing. Soybean sown on June 30 recorded the highest number of pods $plant^{-1}$ which were significantly higher as compared with early on May 20. Devi *et al.* (2014) also reported positive effect of mulching on number of pods per plant.

Sowing dates however did not influence 100 seed weight (Table 2).The proper planting date actually increases efficiency of photosynthesis, transport of photo assimilates and their storage in the seed, which in turn causes increase of performance (Azari and Khajepour, 2003).

Effect of mulching on plant height was not significant in all the three years. However, it was observed that plant height tended to increase with the application of wheat straw mulch over no mulch treatment in different years. Branches $plant^{-1}$ and pods $plant^{-1}$ were not affected significantly with the use of straw mulch. However, in all the three years, mulching recorded relatively higher number of pods $plant^{-1}$ over no mulch treatment. Xue *et al.* (2013)

Table 1: Effect of sowing dates, mulching and seed rates on plant height, branches and pods per plant of soybean.

Treatments	Plant height (cm)			Branches plant^{-1}			Pods plant^{-1}		
	Ist year	IInd year	IIIrd year	Ist year	IInd year	IIIrd year	Ist year	IInd year	IIIrd year
Sowing date									
May 20	102.6	154.1	117.5	9.6	13.6	8.9	99.7	76.9	104.3
June 10	86.7	109.5	97.6	9.5	14.4	9.5	102.7	95.9	120.6
June 30	74.9	99.1	85.1	8.4	12.2	10.1	133.4	105.1	129.4
CD (P=0.05)	**5.7**	**18.8**	**10.4**	**0.8**	**NS**	**NS**	**25.8**	**16.1**	**12.9**
Mulching									
No mulch	87.9	116.5	97.2	9.2	13.6	13.6	107.8	89.9	116.1
Mulch	88.3	125.2	102.8	9.0	13.3	13.3	116.0	95.4	120.1
CD (P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Seed rate (kg ha^{-1})									
60	85.5	114.9	98.7	9.1	13.6	9.7	116.3	94.5	120.8
75	87.3	117.6	101.6	9.0	13.3	9.5	111.0	87.4	118.1
90	91.5	130.1	99.7	9.3	13.3	9.3	108.4	96.0	115.4
CD (P=0.05)	**NS**	**8.1**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 2: Effect of sowing dates, mulching and seed rates on 100 seed weight, seed and stover yield of soybean.

Treatments	100 seed weight (g)			Seed yield (q ha^{-1})			Stover yield (q ha^{-1})		
	Ist year	IInd year	IIIrd year	Ist year	IInd year	IIIrd year	Ist year	IInd year	IIIrd year
Sowing date									
May 20	10.0	10.4	9.6	26.8	28.5	26.1	65.5	91.9	80.7
June 10	10.5	10.6	9.6	30.8	29.3	27.6	46.5	63.6	64.7
June 30	11.3	11.3	10.2	23.9	31.6	28.4	39.1	55.3	54.2
CD (P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**10.8**	**6.6**	**6.4**
Mulching									
No mulch	10.6	10.6	9.7	26.9	29.2	26.6	49.1	69.1	63.8
Mulch	10.7	10.9	9.8	27.4	30.4	28.1	53.2	71.5	69.4
CD (P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**5.2**
Seed rate (kg ha^{-1})									
60	10.7	10.5	9.8	26.8	28.3	27.3	49.9	66.6	69.9
75	10.5	11.5	9.5	28.3	30.3	28.8	50.1	69.9	65.3
90	10.6	10.3	10.1	26.4	30.3	26.7	51.1	74.3	64.4
CD (P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**6.1**	**NS**

reported that under mulching, the enhancement in soybean growth was the result of soil water being used for plant growth and yield rather than the evaporation of soil water. Effect of mulching on 100 seed weight remained non-significant (Table 2).

Influence of seed rates at 60, 75 and 90 kg ha^{-1} on plant height, branches plant^{-1}, pods plant^{-1} and 100 seed weight was also not significant in different years except the plant height during second year which was significantly higher in 90 kg seed rate ha^{-1} as compared to 60 and 75 kg seed rate ha^{-1}. Lone *et al.* (2010) also observed higher soybean plant height in higher seed rate treatments. In similar studies, Ram *et al.* (2011) also reported 62.5 kg/ha to be the optimum seed rate among the three seed rates 50, 62.5 and 75 kg/ha for soybean under Indian Punjab conditions. This might be due to more space, water and nutrient availability with lower seed rate. At higher seed rate, the number of pods per plant decreased due to competition amongst plants for resources like nutrients, moisture, light and space. Seed yield improved with successive delay in sowing from May 20 to June 30 during second and third year whereas increase in yield over early sowing on May 20 was recorded with June 10 sowing date during first year only (Table 2). In all the three years, differences in yield among different sowing dates were found to be non-significant. Relatively poor crop stand on account of crust formation due to rains after sowing on June 30 resulted in low yield under delayed sowing during first year. In general, it was observed that the seed yield improved with delay in sowing date up to June 30. Application of wheat straw mulch @ 6 tonnes ha^{-1} tended to improve the yield over control (no mulch) treatment. However, the difference in yield between mulch and no mulch treatment was not significant in any of the years. The greater soil profile moisture under mulch has important implications in the utilization of water by crop and in soil reactions that control the availlability of nutrients and biological nitrogen fixation (Surya *et al*., 2000) that leads to improved growth and ultimately yield. Since the availability of soil moisture increased the pod number per plant, the yield increase was realised (Bajaj *et al.*,2008). Different seed rates viz 60, 75 and 90 kg ha^{-1} recorded statistically similar seed yield. The results have revealed that seed rate at 60 kg ha^{-1} is adequate for soybean.

Successive delay in sowing reduced the stover yield as compared with early sowing on May 20 and June 10 (Table 2). Maximum stover yield was recorded with early sowing on May 20 and the lowest under delayed sowing on June 30 in all the three years. Mulching with wheat straw also increased the stover yield in different years.

However, significant increase in stover yield with mulch over no mulch treatment was recorded during third year. Devi *et al*. (2014) also reported highest stover yield due to enhanced dry matter accumulation under mulching. Different seed rates did not influence the stover yield during second and third year whereas the highest seed rate at 90 kg ha^{-1} resulted in significantly higher stover yield than 60 kg seed rate ha^{-1} during second year. It was observed that during all the three years seeding date significantly influenced pods per plant but mulching and seeding rate had no significant effect on pods per plant.

NPK uptake: The N uptake by soybean grain was not influenced by mulching treatment but was significantly higher in 75 and 90 kg seed/ha treatment than 60 kg seed ha^{-1} treatment (Table 3) and was also significantly higher in the June 30 and June 10 sowing dates as compared to May 20 sowing dates. Lone *et al*.(2009) reported that the maximum uptake of N in soybean was recorded with seed rate of 80 kg/ha as compared to 60 and 40 kg/ha. The N uptake by soybean straw was significantly influenced by all the sowing dates, mulching and seed rate treatments. It was found that maximum straw N uptake (30.3 kg ha^{-1}) was recorded in May 20 sowing date which was also significantly higher than the other two sowing dates. It was also observed that mulching produced significantly higher straw N uptake (26.2 kg ha^{-1}) than no mulching treatment (23.2 kg ha^{-1}). Under different seed rates the maximum was recorded in 90 kg seed/ha treatment which was significantly better than the other two seed rate treatments. The total N uptake was not significantly influenced by mulching treatment but was significantly affected by different sowing dates and seed rate treatments. The maximum of 140.5 kg ha^{-1} was observed under June 30 sowing date which was significantly more than the other two dates of sowing which remained statistically at par with each other. Seed rate of 75 kg ha^{-1} produced the maximum total N uptake (143.6 kg ha^{1}) which was significantly better than the other two seed rate treatments.

Mulching and different dates of sowing did not have any significant effect on P uptake by soybean grain whereas maximum grain P uptake was recorded under 90 kg seed rate treatment which was significantly on par with 60 kg seed rate ha^{-1} but was significantly more than 75 kg ha^{-1} treatment. The straw P uptake was significantly influenced by different sowing dates and mulching. When different sowing dates were compared it was found that maximum P uptake by straw was observed under May 20 sowing date which was significantly higher than the other two dates of sowing which remained statistically at par with each other. The total P uptake was maximum in May 20 sowing which was significantly more than the other two dates. Mulching also recorded significantly higher total P uptake (18.9 kg ha^{-1}) as compared to no mulching (16.1 kg ha^{-1}). When different seed rates were compared it was observed that maximum P uptake was recorded under 90 kg seed ha^{-1} which was significantly higher than 75 kg seed rate treatment but statistically on par with 60 kg seed rate/ha. The P uptake

Table 3: Influence of sowing dates, mulching and seed rates on N,P and K uptake by soybean.

Treatments	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			K uptake (kg ha^{-1})		
	Grain	**Stover**	**Total**	**Grain**	**Stover**	**Total**	**Grain**	**Stover**	**Total**
Sowing date									
May 20	102.8	30.3	133.1	10.9	9.1	20.0	53.9	39.3	93.2
June 10	107.2	24.7	131.9	10.6	5.9	16.5	54.2	32.4	86.6
June 30	118.4	22.1	140.5	12.3	4.3	16.6	51.8	29.2	81.0
CD (P=0.05)	**4.5**	**2.9**	**4.6**	**NS**	**2.4**	**2.6**	**NS**	**5.9**	**5.7**
Mulching									
No mulch	110.6	23.2	133.9	11.2	4.9	16.1	51.8	31.7	83.5
Mulch	104.8	26.2	131.0	10.6	8.3	18.9	52.7	34.4	87.1
CD (P=0.05)	**NS**	**1.4**	**NS**	**NS**	**3.1**	**1.7**	**NS**	**1.7**	**NS**
Seed rates (kg ha^{-1})									
60	104.8	23.1	127.9	11.9	4.3	16.2	52.1	29.5	81.6
75	118.4	25.2	143.6	9.4	5.1	14.5	50.1	33.1	83.2
90	108.3	27.3	135.6	13.4	5.1	18.5	50.1	31.7	81.8
CD (P=0.05)	**3.6**	**1.8**	**5.1**	**2.8**	**NS**	**3.1**	**NS**	**NS**	**NS**

increased with the increase in the seed rate (Lone *et. al.*, 2009) and Kumar and Badiyala (2004).

The K uptake by soybean grain remained statistically at par under different sowing dates, mulching and seed rate treatments. The straw K uptake was also not influenced significantly under different seed rate treatments but it was significantly higher in mulching treatment (34.4 kg ha^{-1}) than no mulching (31.7 kg ha^{-1}). It was also significantly higher in May 20 sowing date as compared to the other dates of sowing which within themselves remain statistically at par with each other. The total K uptake was also not significantly influenced under mulching and seed rate treatments but was significantly higher in May 20 sowing date as compared to other dates of sowing.

It may be concluded that soybean sown on June 30, recorded higher seed yield as compared with its early sowing on May 20 and June 10. Similar yield of soybean with 60, 75 and 90 kg seed rate ha^{-1} revealed that use of 60 kg seed rate ha^{-1} is adequate for soybean and mulching proved beneficial for soybean.

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