Indian Journal of Agricultural Sciences **81** (10): 941–4, October 2011

Tractor-drawn broad bed furrow seed drill machine to overcome moisture stress for soybean (*Glycine max*) in Vertisols

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Received: 21 February 2011; Revised accepted: 24 May 2011

ABSTRACT

A tractor-drawn broad bed furrow (BBF) seed drill machine for soybean [*Glycine max* (L.) Merrill] was conceived, fabricated and farm validated. It effectively operates in Vertisols and associated soils and is attachable to the tractor for facilitating formation of broad bed along with furrows on both the sides of the beds of desired width and depths and subsequent sowing in one go. Plant population mortality in soybean with tractor-drawn BBF seed drill for Vertisols was reduced in the range of 14–19% as compared to flat bed under the vagaries of monsoon which subsequently resulted in yield enhancement to the extent of 18.65%. Study also indicated that tractor-operated BBF seed drill specifically fabricated for individual tractor performed better in Vertisols and under prevailing field draft conditions.

Key words: Plant population, Soybean, Tractor-operated broad bed furrow seed drill, Vertisols

Soybean [*Glycine max* (L.) Merrill] is established as premier crop covering an area of 9.21 million ha with the estimated production of 12.59 metric tonnes in India. The crop is grown under rain fed conditions and experiences water stress due to uncertain onset, quantum and ill distributed monsoon.

The major command area for soybean lies on Vertisols and associated soils of Central India, which are prone to severe runoff and water stagnation of different degree depending on the topography and the intensity of storms received during monsoon season. In addition, the crop suffers from intermittent moisture stress leading to lower yields. These soils have a large potential of increasing agricultural production, provided appropriate technologies for conservation and management of natural resources, particularly soil and rainwater management, are widely implemented. Upland crops grown on these soils in high rainfall areas (>1 000 mm), mainly soybean and maize (*Zea mays*), are prone to temporary waterlogging and anaerobic conditions (Rajput *et al*. 2009). Land treatments (raised-sunken bed system, ridges and furrows, broad bed and furrows) increased *in situ* soil moisture conservation, minimized runoff, and soil erosion (Singh *et al*. 1999, Nagavallemma *et al*. 2005) and increased the yield of principal crops grown in the region (Mandal *et al*. 2005, Rajput *et al*. 2009).

Therefore, to save the crop from moisture stress during crop growth period and to minimize the cost of cultivation without compromising with sustainability, a planting machine suitable for simultaneously providing a broad bed and furrow and planting crop on modified land configuration on these swell shrink soils was fabricated and farm validated at the Directorate of Soybean Research, Indore.

MATERIALS AND METHODS

The developed BBF seed drill was validated for its efficacy for three consecutive cropping seasons in soybean (*kharif* 2007–09) at Research farm of Directorate of Soybean Research, Indore (situated at 22º 4'37''N latitude, 75º 52'7''E longitude and altitude of 540 m above the mean sea level) in a randomized block design with 12 replications. The rainfalls during the seasons were also recorded. The experiments were carried out on deep black cotton soils with pH 7.85, low to medium in organic carbon and available phosphorus and high in potassium (Typic Chromusterts and Lithic Vertic Ustochrepts). Before sowing 20 kg/ ha Nitrogen, 60 kg/ ha Phosphorus and 20 kg/ ha Potassium were applied in the form of commercial fertilizers.

The tractor-operated broad bed furrow seed drill (Fig 2) is suitable for planting on Vertisols and associated soils and is attachable to 40-45 PTO hp range tractors. This seed drill has been made of box section mild steel (8 mm). This tractor-

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Table 1 Resultant plant population (no./m^2) and seed yield (kg/ha) in field plot from broad bed furrow seed drill

Treatment	2007		2008		2009		Mean	
	Plant population (no./m^2)	Seed yield (kg/ha)	Plant population (no./m^2)	Seed yield (kg/ha)	Plant population (no./m^2)	Seed yield (kg/ha)	Plant population (no./m^2)	Seed yield (kg/ha)
Broad bed furrow seed drill	46.75	1351	43.58	1350	45.58	1251	45.30	1317
Flat seed drill	39.25	1186	38.16	1083	39.42	1060	38.94	1110
CD at 5%	2.12	23.86	1.16	26.43	1.50	29.61	1.59	26.63
CD at 1%	2.99	33.68	1.64	37.31	2.12	41.79	2.25	37.59

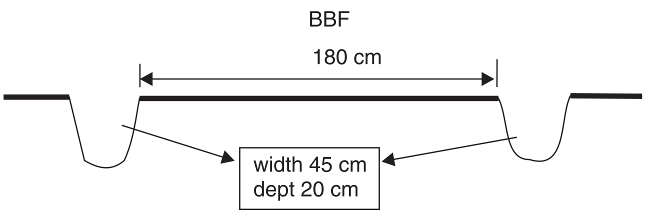

Fig 1 The profile of broad bed furrow land preparation method

operated BBF seed drill is capable of making furrows of desired depth and width at both the sides of the bed (Fig 1) and can be used for simultaneous sowing of crop in one operation. This seed drill is capable of sowing 5, 4 or 3 rows as desired on the bed with rail mechanism frame provided on machine It also has the facility to change the row-to-row distance as it has the rail type frame on which the shanks of the furrow opener for sowing are mounted to facilitate changing of row-to-row distance. It forms furrows on both the sides of the row along with sowing operation. The BBF seed drill has the provision to increase or decrease the depth of the furrows. The furrows are useful to drain out excessive rainwater during heavy storms and for storing rainwater in furrows for enriching soil moisture through percolation in case of deficit rainfall. The soil moisture thus stored sustains the crop during dry spells. The above said BBF seed drill is provided with seed covering device which is attached to the individual tines. The seed covering device has a V notch at the lower end which is precisely designed to put desired soil over the dropped seed. The device saves the seed from being picked up by birds or rats. The height of the device is such that it is compatible with the seed to be sown. The machine has a provision of a weeding device (horizontal shearing type) between the rows which helps weeding simultaneously along with sowing operation. This saves one operation of weeding just after sowing.

The BBF system is known to compliment soybean crop to express its potentials either in excessive or deficit rains. The machine developed at the Directorate can be fabricated by any efficient implement manufacturers conveniently at a price of ₹ 58 000. The tractor-drawn BBF seed drill needs suitable PTO hp tractor matching with the draft of the soil on which it is operated. The seed drill should follow the three point linkage design parameters for successful operation of the machine. It is suggested to always get this device manufactured for individual tractors for better fitment as per three-point linkage category and horsepower so as to adjust to the variation in soil and draft conditions. The BBF seed drill is versatile for providing channels and beds of desired dimensions depending on the need of the farmer.

The plant population per square meter from 10 randomly selected places from twelve replicated plots (each plot- 50 m × 2.25 m) for each of the above two treatments were counted. The yield data from each plot was recorded. The weight of the seed drill is 470 kg. Length of the frame is 3.10 m and width is 0.56 m. The said machine and its performance have been described in the following text. The data was subjected for statistical analysis to test its statistical significance.

RESULTS AND DISCUSSION

The results on validation of BBF machine (Fig 2) brought out that the plant population of soybean was significantly higher when the crop was planted using the machine as compared to planting on flat land by normal seed drill. Analysis of weather data revealed that the rainfall during season (June–October) was 873.78 mm in 2007, 549.39 in 2008 and 859.59 mm in 2009 (Fig 3). The plant population ranged 14–19% higher on planting soybean using BBF machine as compared to planting on flat land with normal seed drill (Table 1). An average increase in yield was 18.65% during the three years of testing. This indirectly indicated that use of BBF machine promotes better germination and

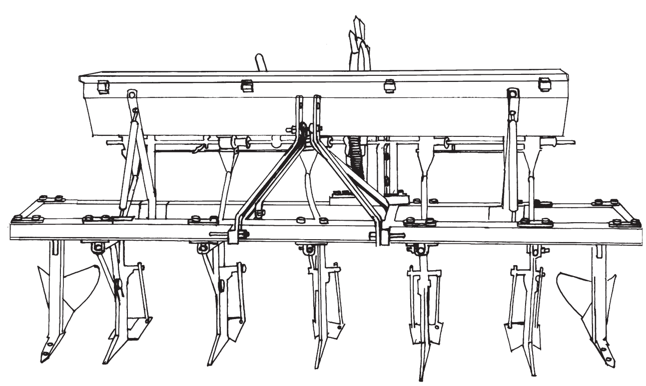

Fig 2 Broad bed furrow seed drill

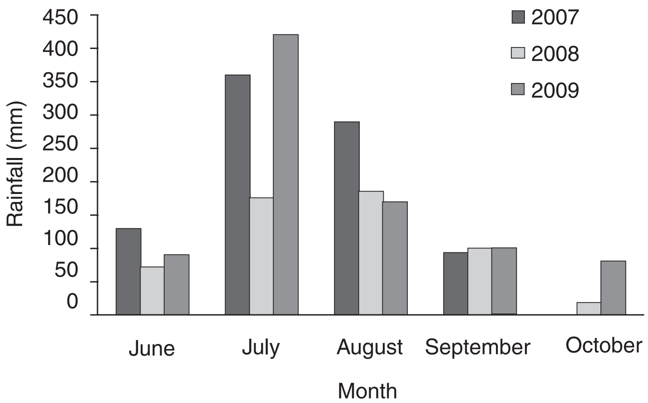

Fig 3 Rainfall (mm) at Indore during soybean crop seasons

emergence of the crop as compared to planting by normal seed drill. As far as the seed yield is concerned, significant increase over normal seed drill planting was noted on planting with BBF machine.

The ridges and BBF developed by the International Crops Research Institute for semi-arid tropics (ICRISAT, India) for increasing the productivity of semi-arid poorly drained Vertisols, provide more opportunity for infiltration of rainwater and at the same time prevent waterlogging of the crop growing on the bed. An additional advantage is recycling of stored water for lifesaving irrigation. Mishra *et al.* (2003) observed during normal rainfall years, BBF landform treatment alleviated waterlogging and increased productivity of soybean. The BBF landform stored more moisture in soil than the flat on grade (FOG) treatment; BBF also had low cone penetration resistance of soil than the FOG treatment. The BBF treatment also recorded reduced runoff (10.6%) as against the runoff from FOG (18.6%). Several farmers also evaluated BBF and flat landform treatments for shallow and medium-depth black soil using different treatment combinations. Farmers obtained 250 kg more pigeonpea and 50 kg more maize/ha using BBF on medium–depth soils than from the flat landform treatment (Sreedevi *et al*. 2004). Wani *et al*. (2005) also observed the performance of the broad bed and furrow system was consistently superior to the traditional system in reducing annual run-off, soil loss, and peak run-off rate. They remarked when rainfall was very low and moisture conservation was crucial, the broad bed and furrow system conserved most of the annual rainfall. In contrast, during high rainfall, this system produced substantial run-off. A system of broad bed and furrow system has been found to be effective and sustainable for enhancing productivity and protecting environment in ensuring good surface drainage of water, control of erosion and in conserving water and improving physical, biological and chemical properties of soil profile on Vertisols. Using broad beds and furrows, balanced nutrient management and short duration soybean cultivars in the rainy season, farmers of Madhya Pradesh have been able to take a crop of chickpea or wheat during dry season and thereby double their income. Many such simple steps in soil–water–crop management can lead to major advances in both crop output and farmers' income (Swaminathan 2007). The benefits of BBF also have been documented by Chandrasekharan and Pandian (2009).

In Ethiopia, Welderufael and Woyessa (2009) showed that both the BBF and the ditch drainage methods gave about 33% and 22% more grain yield than the flat treatment, respectively. While, Rajput *et al.* (2009) in their study found grain yields of wheat (*Triticum aestivum*) and chickpea (*Cicer arietinum*) were higher in raised-sunken bed system (RSBS) system than in the flatbed system (FBS) of planting. Soybean (*Glycine max*) yield increased nearly 100% with the ridge-furrow system (RFS) and about 55% in BBF system compared with the flat bed planting. In our study, there was an increase in yield to the extent of 14–25 % (average being 19%) over normal planting on flat land. It can be noted that during *kharif* 2008, which a drought year, the yield increase was maximum (25%). Respectable yields in crop planted on flat land with normal seed drill also confirm the resilience of the soybean crop under deficit moisture conditions.

The yield advantage and better soil environment for crop establishment and growth of soybean crop in addition to reduced cost on preparation of land suggests that the soybean crop should be planted on BBF systems using the efficient developed machine for higher net returns by the soybean growers. The above said seed drill can be used for *rabi* crops with or without the two furrow openers (channel openers). Mandal *et al*. (2005) also suggested that the Indian Government should enact special legislation or introduce incentives for the Vertisol farmers who mostly use old cultivation practices to adopt improved soil management technology for production stability on a large scale as well as retarding the sub-soil sodification by constant pedogenesis of $CaCO_3$.

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