Bedding, Plant Population, and Spray-on Mulch Tested to Increase Dry Bean Yield

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Abstract. This experiment was conducted to determine the effects of bed type (single or parallel raised bed vs. nonbedded); plant density (1991: $\approx 148,300$ or $269,500$ plants/ha; 1993: $\approx 148,300$, $269,500$, or $432,400$ plants/ha); and use of black or white degradable mulch vs. nontreated soil on total and marketable yields and number of marketable seed per kilogram (seed count) of 'Fleetwood', an erect bush, white-seeded navy bean (*Phaseolus vulgaris* L.). Spray-on mulch degraded before canopy closure, but a residue was present at harvest. In 1991, treatments did not affect yield or seed count. In 1993, bedding did not affect yield over nonbedded seedbeds. Black spray-on mulch increased marketable yield over plants grown with white spray-on mulch. Total and marketable yields were significantly higher at $269,500$ than at $148,300$ plants/ha. Bed type and plant density did not affect seed count, but seed count increased with black spray-on mulch. Dry beans should not be grown on beds under soil conditions such as those in our experiment. White spray-on mulch had no beneficial effect, but using black mulch needs additional evaluation. Planting at $269,500$ plants/ha likely will yield ≈ 2 Mg seeds/ha in most years.

Dry (navy) bean (*Phaseolus vulgaris*) yield is ≈ 2.24 Mg·ha⁻¹ in the United States (U.S. Dept. of Commerce, 1989), and yields could increase if improved cropping methods were adopted (Coyne, 1989). To be accepted, a new method must deliver a product at a level at least as good as the method it would replace. Mulch and raised beds are used in vegetable production to improve yields; however, dry beans generally are not cultured on raised beds. Harvest methods for dry beans are not compatible with plastic mulch, but degradable, spray-on mulch might be useful because it can be applied preplant or preemergence and can increase soil temperature (Russo, 1991).

Plant population can modify effects of cultural methods. Populations $\leq 980,000$ plants/ha produced yields ≤ 4.48 Mg·ha⁻¹ (Nienhuis and Singh, 1985; Smittle and Williamson, 1976). However, LeBaron et al. (1959) and Kahn et al. (1981) reported that plant population did not affect dry bean yield. When 'Sanilac' navy bean populations were grown with 15-cm rather than 10-cm in-row spacing, yield increased by 35% (Sullivan and Bliss, 1981). This experiment was designed to determine if bedding, plant population, and spray-on mulch influence dry (navy) bean yield.

Experiments with 'Fleetwood' navy bean,

an erect bush genotype (Nuland et al., 1983), were conducted in 1991 and 1993 on a Bernow fine-loamy, siliceous, thermic Glossic Paleudalf soil in Lane, Okla. Fertilizer was preplant-incorporated at recommended rates (McCraw and Motes, 1987). Plots were 3.1 m long $\times$ 1.8 m wide, oriented east to west on 2.7-m centers, and separated lengthwise by 1.8-m nonplanted alleys. Soil was either level or shaped into a single bed (1.25 m across the top) or two parallel beds (each 0.5 m across the top) with 0.25 m of nonbedded space between them. Beds were 20 cm high. The equivalent of 50 mm of water was supplied by drip irrigation (two lines per plot; emitters 23 cm apart; 0.25 liter/h per emitter) when there was no rainfall for 1 week.

Within-row plant spacing was 7.6 cm. Plant populations were manipulated by changing the spacing between rows. Nonbedded and single beds were planted with either two, four, or six rows, but parallel beds were planted with two or four rows. Spacing between two rows was 76 cm; spacing between each of four rows, 38 cm; and spacing between each of six rows, 19 cm. In 1991, populations were $\approx 148,300$ or $269,500$ plants/ha; in 1993, they were $\approx 148,300$, $269,500$, or $432,400$ plants/ha. Following planting, black or white, spray-on, degradable mulch (Earthguard; Continental Products Co., Euclid, Ohio) was applied at 105 ml·m⁻² and at 414 kPa with a tractor-mounted centripetal pump through four 8006 flat fan nozzles. Controls were nontreated soil.

Pods harvested at 15% to 18% seed moisture were mechanically threshed (Seedboro Equipment Co., Chicago). Seed retained by a 0.5×1.9 -cm screen on a shaker (Seedboro Equipment Co.) were considered marketable. Weights of passed and retained seed were recorded. Unblemished seeds per 100-seed subsamples of retained seed were counted. Marketable seed yield was estimated by multiplying retained seed weight by the unblemished seed percentage. The number of seeds in 230-g subsamples of retained seed was determined. Factorial experiments included three bed-type combinations; two or three plant population in 1991 or 1993, respectively; and three spray-on mulch treatments replicated three times in randomized complete blocks. Data were analyzed using the general linear models procedures in SAS (SAS, Cary, N.C.). Continuous quantitative data were analyzed to determine if they fit linear distributions.

By plant emergence, both mulches were severely degraded, but patches of black mulch were present at harvest. In 1991, over main effects of bed type, plant population, and mulch, average total and marketable yields were 2.4 and 2.2 Mg·ha⁻¹, respectively; the number of seeds averaged 7687/kg. In 1993, total and marketable yields were affected by plant population and mulch, and the number of seeds was

Table 1. Effect of bed type, plant population, and spray-on mulch on total and marketable yields and number of marketable seed per unit weight for 'Fleetwood' navy bean in 1993.

Variable	Yield (Mg·ha ⁻¹)		No. marketable seed (per kg)
	Total	Marketable	
Bed type			
Nonbedded	1.6 a ²	1.2 a	6460 a
Single	1.8 a	1.3 a	6640 a
Two parallel	1.9 a	1.4 a	6690 a
Mulch			
None	1.8 ab	1.3 ab	6470 b
White	1.6 b	1.2 b	6500 b
Black	1.9 a	1.4 a	6780 a
Population (plants/ha)			
148,300	1.5	1.1 b	6530
269,500	2.0	1.4 a	6610
432,400	1.8	1.3 a	6630
Linearity ³	Q*	NS	NS
Nonlinear significance	--- ^x	**	NS
Model cv	20.1	24.0	6.6

²Mean separation in columns by Duncan's multiple range test ($P \leq 0.05$).

³NS indicates that data did not fit a significant linear, quadratic (Q), or cubic distribution, and * indicates significant at $P \leq 0.05$.

^xData fits linear distribution. There were no interactions between treatments.

NS, **Nonsignificant or significant at $P \leq 0.01$.

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affected by mulch. Neither yield nor number of seed per kilogram was affected by bed type (Table 1). Total yield was highest at 296,500 plants/ha. Marketable yield did not fit any linear distributions and increased significantly with an increase to 296,500 plants/ha in population. Total and marketable yields from plants grown with black mulch were higher than those from white mulch; yields from plants on nontreated soil were intermediate in yield. Number of marketable seed was not affected by plant population but was highest on black spray-on mulched beds. There were no significant interactions for yield or number of seed.

Dry (navy) bean yields from 1.5 to 2.0 Mg·ha⁻¹ were produced with between 148,300 and 296,500 plants/ha, of which 72% were marketable. Spray-on mulch can affect soil temperature and may affect early plant development. Neither black nor white spray-on mulch improved yield over plants on nontreated soil, regardless of bedding. Further-

more, it appears that the black spray-on mulch led to a decrease in seed size, reducing marketable value. Because the black mulch was severely degraded at plant emergence, it likely had minimal effects on plant development through pod maturity. However, the statistical response of seed size to black mulch suggests that there may be breakdown products from the mulch that affect plant development. Using spray-on mulch and bedding are not recommended as cultural practices for this dry bean cultivar.

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