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Research Paper

Effect of sowing date and weed management on productivity and economics of rainfed mungbean (*Vigna radiata*)

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ABSTRACT

A field experiment was conducted during the rainy (*kharif*) season of 2013 and 2014 at Angul, Odisha, to study the effect of sowing date and weed management on crop growth, yield, weed control, economics and nutrient uptake of mungbean [*Vigna radiata* (L.) Wilezek]. The experiment consisted of 3 sowing date and 6 weed management treatments. The pooled results revealed that, the crop sown on June 20, resulted significantly higher plant height, dry matter accumulation, seeds/pod, nodules/plant, seed yield (1.0 t/ha), net returns (₹26,100/ha) and weed control efficiency (68.1%). Application of imazethapyr @ 100 g/ha at 20 days after sowing (DAS) followed by (*fb*) 1 hand-weeding at 40 DAS resulted in significantly higher plant height, dry matter accumulation, dry matter efficiency, pods/plant, seeds/pod, nodules/plant, nodules dry weight, seed yield (1.17 t/ha), harvest index (29.7%), monetary returns (₹872/ha/day) and benefit: cost ratio (2.18). The same treatment also recorded the maximum weed control efficiency (87.9%), which resulted in significant reduction in both weed density (38.0/m^2) and weed dry weight (28.6 g/m^2). In contrast to nutrient uptake by mungbean crop, the decreased nitrogen, phosphorus and potash removal by weeds was recorded upto to 88.5% under weed management treatments.

Key words: Economics, Mungbean, Nutrient uptake, Sowing date, Weed management, Yield

Mungbean is the third most important grain legumes crop after chickpea and pigeonpea grown and consumed in India. It is a good source of protein and minerals. Its protein quality is similar to or better than other grain legumes Mungbean is the major pulse crop of Odisha with a total coverage of 0.86 million ha. The area under mungbean crop in Angul district is 0.03 million ha with a productivity of 0.45 t/ha, which is at par with state average yield (Samant, 2014).

Among the various agronomic practices, sowing time is the most important factor influencing its yield, which differs from region to region and variety to variety. But lack of awareness among farmers about optimum sowing date is one of the reasons of its low productivity. In early sowing of mungbean, a second crop can be grown on the same field in early September for higher income with increasing soil fertility. Any delay in sowing time not only reduces the yield but also creates problem for harvesting of the same. The foremost information on time of sowing therefore needs to be specified. Sowing date is also one of the major non-monetary input affecting growth, yield and its contributing characters. It is considered as important factor which is having the vast potential to explore the maximum yield (Palsaniya *et al*., 2016).

Weed management is the most important agronomic aspect that plays a vital role in exploiting the yield potential of rainy season (*kharif*) mungbean. Weeding and hoeing are common cultural methods for mungbean. Manual weeding at right stage is difficult, time consuming and expensive due to intermittent rainfall during rainy season and scanty labour. Weeds compete with crop plant for water, nutrient, light and space during all the crop growth stages in hot and humid weather. Presence of weeds has been reported to reduce the seed yield of mungbean by 35%. Integration of one herbicide with one hand-weeding provided better growth, yield attributes and consequently higher yield (Raman and Krishnamoorthy, 2005). Therefore, there is an urgent need to move from costly manual-mechanical weed control to an integrated weed control. In the more developed agricultural systems, herbicides have already replaced mechanical weed control. Unavailability of labours at the time of weeding resulting in sever field infestation, which make mechanical weeding ineffective,

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tedious and costly. Under such circumstances, chemical control of weeds may be the viable and cost effective alternative for this crop. Effective herbicide at appropriate rate may prove as an effective weed control method and replace conventional methods of weed control (Chaudhari *et al.,* 2016). Herbicides can be used as an alternative of manual or mechanical weeding. Previously, weed control through herbicides was considered a costly proposition. However in recent times availability of low-dose, high potency, non-residual, broad spectrum herbicides has provided great opportunity to accomplish effective weed control at much lower cost than mechanical methods. Imazethapyr, a post-emergence broad spectrum herbicide, was recommended for use in rainy-season pulses like pigeonpea, urdbean and mungbean (Kumar, *et al.*, 2016). Weed management in mungbean not only increased N, P and K uptake by seed and stover of crop, but also it decreases the total N, P and K uptake by weeds over weedy check (Komal *et al*., 2015). Therefore, the present investigation was undertaken with the objective of finding suitability of sowing date and weed management on growth, yield, weed control, economics and nutrient uptake in rainfed mungbean.

MATERIALS AND METHODS

The experiment was conducted during rainy (*kharif*) season of 2013 and 2014 at Angul, Odisha to study the effect of sowing date and weed management on growth, yield, weed control, economics and nutrient uptake of mungbean. The experiment site is located at the Instructional farm, Krishi Vigyan Kendra (20°49' N, 85°04' E and an altitude of 195 m above mean sea-level). The soil of the experimental field was sandy loam with slightly acidic in reaction (*p*H 5.5), low in organic carbon (0.48%) and available nitrogen (236.4 kg/ha), medium in available phosphorus (14.9 kg/ha) and potassium (172.5 kg/ha). Total rainfall received during the crop season was 956.5 mm. The average relative humidity during the experimental season fluctuated between 75 to 93% in the morning time and 41 to 66% in the evening time. Mean weekly maximum temperature fluctuated between 36.1 and 29.6°C and minimum temperature 22.7 and 27.0°C during the crop growth period.

The experiment was laid out in split-plot design keeping 3 sowing date, viz. June 20, July 5, July 20 in mainplots and 6 weed management practices, viz. imazethapyr 100 g/ha at 20 days after sowing (DAS); mechanical weeding by finger weeder at 20 DAS; imazethapyr 100 g/ha 20 DAS followed by (fb) 1 hand-weeding (HW) at 40 DAS; mechanical weeding by finger weeder at 20 DAS fb 1 HW at 40 DAS; hand weeding at 20 DAS fb hoeing at 40 DAS and weedy check in sub-plots during both the years and replicated 3 times.

Mungbean 'OBGG 52' was sown in a plot size of 5 m × 5 m with 20 kg seed/ha at 30 cm apart, as per the sowing-date treatments. Thinning was done 15 DAS to maintain optimum plant population. The recommended dose of fertilizers, i.e. 20, 40 and 40 N, P and K kg/ha was used for all the treatments and pests and diseases control measures were followed as per need of crop. Imazethapyr was applied through knapsack sprayer fitted with a flat-fan nozzle using a spray volume of 500 litres of water per hectare. Mechanical weeding was done by finger weeder as per treatment. Observation on plant growth (plant height, nodules/plant, nodules dry weight/plant, dry matter accumulation and dry matter efficiency), yield attributes (pods/plant and seeds/plant) and yield (seed, stover, harvest index) were recorded following standard procedures. Weed population were counted from 2 places selected randomly by throwing a metallic quadrate of size 0.5 m× 0.5 m at 40 days after sowing in each plot. The weed dry weight was recorded by drying of weeds in hot air oven (65°C for 72 hours). The dry-matter efficiency was calculated as the percent of total dry matter production (seed and stover yields) accumulated in seed per day (Singh and Chaudhary, 2016). The weed control efficiency (WCE) was calculated by using the formula (Kondap and Upadhyay, 1985) on weed dry weight basis.

Economic analysis was done by calculating cost of cultivation, gross returns, net returns and benefit: cost ratio (B:C). Prevailing price of inputs in the market during both the year were used to calculate the economics. The B:C ratio was worked out on the basis of gross returns and cost of cultivation. Monetary returns was calculated by dividing gross return by total crop duration. Available soil nutrients as well as nutrient content and their uptake by crop and weeds were determined by adopting standard procedures (Jackson, 1973). After estimation of NPK concentration in weeds, mungbean seed and stover under different treatments, NPK uptake was calculated by nutrient concentration with respective yields. All the data obtained for 2 years were pooled and statistically analyzed applying the techniques of analysis of variance and the significance of different sources of variations were tested by error mean square of Fisher Snedecor's 'F' test at probability level 0.05 (Cochran and Cox, 1957). Critical difference (CD) values at P=0.05 were used to determine the significance of difference between mean values of different parameters.

RESULTS AND DISCUSSION

Growth parameters

Significant differences were observed due to sowing date and weed management practices on crop-growth parameters (Table 1). The plant height, nodules/plant and dry

matter accumulation were significantly higher in June 20 sowing than July 20 sowing, which might be owing to longer period for photosynthesis and growth in early sowing.

Significant differences in plant height, dry matter accumulation, nodules/plant and nodules dry weight/plant were recorded owing to weed management practices. Application of imazethapyr 100 g/ha 20 DAS fb 1 HW at 40 DAS recorded the maximum plant height, dry matter accumulation, nodules/plant and nodules dry weight/plant, which were at par with mechanical weeding by finger weeder at 20 DAS fb 1 HW at 40 DAS and was significantly superior to rest of the treatments, which might be due to less crop-weed competition. The increase in nodule number probably due to increase in aeration of rhizosphere in disturbed soil condition. Similar kind of results were reported by Pramanick *et al.* (2013).

Yield attributes

All yield attributes were significantly affected by the sowing date and weed management practices (Table 1). Seeds/pod was found to be significantly higher on June 20 than July 5 and July 20 sowing attributing to better translocation of photosynthates to seed. The reduction in yield attributes in delayed sowing might be due to decrease in cell-division and cell expansion and owing to their genetic variability. Weed management practices showed significant variation in different yield attributes. Imazethapyr 100 g/ha 20 DAS fb 1 HW at 40 DAS resulted maximum pods/plant and seeds/pod, which was at par with mechanical weeding by finger weeder at 20 DAS fb 1 HW at 40 DAS and significantly higher than rest of the treatments, which might be owing to its higher plant height and dry matter accumulation. These results are in agreement with the findings of Chaudhari *et al*. (2016).

Weed control

Influence of sowing date on weed control was not perceptible. However, early sowing of mungbean on June 20 recorded (Table 1) the maximum weed-control efficiency with reduction in both weed density and weed dry weight as compared to delayed sowing on July 5 and July 20 (Soomro and Khan, 2003). Among different weed management practices, weed-control efficiency was maximum with imazethapyr 100 g/ha at 20 DAS fb 1 HW at 40 DAS which was followed by mechanical weeding by finger weeder at 20 DAS fb 1 HW at 40 DAS and HW at 20 DAS fb hoeing at 40 DAS (Table 1). All the weed control

Table 1. Effect of sowing date and weed management practices on crop growth, yield attributes and weed control of mungbean. (pooled data of 2 years)

Treatment	Plant height at harvest (cm)	Dry-matter accumulation at harvest (g/m^2)	Pods/ plant	Seeds/ pod	Nodules/ plant at post flowering	Nodules dry weight (mg/plant)	Weed density at 40 DAS (No/m^2)	Weed dry weight at 40 DAS (g/m^2)	Weed-control efficiency (%)
Sowing date									
June 20	63.1	275.7	26.4	6.7	12.1	1.90	111.7	75.4	68.1
July 5	61.6	258.4	25.7	6.5	10.6	1.76	119.9	79.7	66.3
July 20	55.2	246.6	24.9	5.8	10.1	1.66	120.3	83.5	64.7
SEm±	1.48	4.31	0.37	0.08	0.11	1.53	5.24	1.77	–
CD (P=0.05)	5.82	16.91	NS	0.33	0.41	NS	NS	NS	–
Weed management practices									
Imazethapyr 100 g/ha at 20 DAS	57.6	259.2	26.4	6.3	11.1	1.72	83.7	66.9	71.7
Mechanical weeding by finger weeder at 20 DAS	62.8	251.0	24.6	6.7	11.4	1.85	87.1	73.2	69.0
Imazethapyr 100 g/ha 20 DAS fb 1 HW at 40 DAS	65.2	295.5	31.2	7.2	12.7	2.26	38.0	28.6	87.9
Mechanical weeding by finger weeder at 20 DAS fb 1 HW at 40 DAS	64.8	280.4	28.5	6.9	12.5	2.21	47.7	34.9	85.2
HW at 20 DAS fb hoeing at 40 DAS	55.4	262.1	23.5	5.6	9.5	1.37	52.5	37.1	84.3
Weedy check	54.0	213.3	19.7	5.2	8.3	1.22	394.8	236.3	–
SEm±	2.20	8.66	0.51	0.11	0.21	0.01	3.70	1.66	–
CD (P=0.05)	6.35	25.01	1.48	0.32	0.60	0.02	10.67	4.79	–

FB, followed by; DAS, days after sowing; NS, non-significant; HW, hand weeding

treatments significantly reduced both weed density and weed dry weight as compared to weedy check, where maximum weed growth observed during entire crop-growing period. This might be due to effective control of weeds during early stages of crop growth by herbicides and in later stages removal of weeds by HW. These findings are in agreement with Chhodavadia *et al.* (2013).

Yield

Pooled analysis of 2 years data (Table 1) showed significant differences in seed yield, stover yield and harvest index with different sowing date and weed management practices. Maximum seed and stover yields was obtained when sown on June 20, which was statistically at par with July 5 and significantly superior to July 20 sowing due to long vegetation period of the crop and higher yield attributing characters. The harvest index was maximum in July 5 sowing for partitioning of biomass from vegetative to reproductive organ. Similar types of differences among sowing dates were observed by Palsaniya *at el*. (2016). Among the weed management practices, imazethapyr 100 g/ha 20 DAS fb 1 HW at 40 DAS produced significantly higher seed and stover yields and harvest index than other treatments could be owing to better weed control, which ultimately increased the values of yield attributes (Chhodavadia *et al.*, 2013). In addition to this, the least weed density and weed dry weight were also contributed for better seed yield. Higher stover yield was attributed to favourable effect on growth characters by avoiding crop weed competition. This was followed by mechanical weeding by finger weeder at 20 DAS fb 1 HW at 40 DAS and weedy check plot recorded the lowest seed and stover yields and harvest index due to higher weed interference.

Economics

Significantly higher gross returns, net returns, monetary returns and benefit: cost ratio were obtained with June 20 sowing which were at par with July 5 and significantly higher than July 20 owing to higher seed yield (Table 2).

Among different weed management practices, application of imazethapyr 100 g/ha at 20 DAS fb 1 HW at 40 DAS recorded the highest gross returns, net returns and monetary returns, which were at par with mechanical weeding by finger weeder at 20 DAS fb 1 HW at 40 DAS and significantly higher than rest of the treatments. This was due to higher seed and stover yields of the crop obtained from the above treatments and lower cost of cultivation over rest of the treatments. Maximum benefit: cost ratio among the weed management practices was recorded under mechanical weeding by finger weeder at 20 DAS fb 1 HW at 40 DAS. This might be due to lower cost of cultivation with saving of inputs like herbicide and labour. The lowest net returns and benefit: cost ratio among the weed control treatments was obtained under HW at 20

Table 2. Effect of sowing date and weed management practices on yield and economics of mungbean (pooled data of 2 years)

Treatment	Dry-matter efficiency (%/day)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)	Gross returns (×10³₹/ha)	Net returns (× 10³₹/ha)	Monetary return (₹/ha/day)	Benefit: cost ratio
Sowing date								
June 20	0.43	1.00	2.56	28.2	49.0	26.1	753.6	2.18
July 5	0.45	0.99	2.42	28.9	48.0	24.2	738.3	2.04
July 20	0.43	0.91	2.30	28.1	44.5	19.4	684.1	1.75
SEm±	0.01	0.02	0.04	0.31	0.9	0.8	13.6	0.06
CD (P=0.05)	NS	0.07	0.15	NS	3.5	3.1	53.5	0.23
Weed management practices								
Imazethapyr 100 g/ha at 20 DAS	0.44	0.99	2.48	28.6	48.3	24.0	743.4	2.03
Mechanical weeding by finger weeder at 20 DAS	0.44	0.95	2.36	28.7	46.1	23.3	709.6	2.06
Imazethapyr 100 g/ha 20 DAS fb 1 HW at 40 DAS	0.46	1.17	2.76	29.7	56.7	30.3	872.1	2.18
Mechanical weeding by finger weeder at 20 DAS fb 1 HW at 40 DAS	0.45	1.03	2.62	29.5	53.2	28.3	817.7	2.19
HW at 20 DAS fb hoeing at 40 DAS	0.44	0.89	2.20	28.8	43.5	18.8	669.2	1.80
Weedy check	0.39	0.71	2.15	25.1	35.1	14.7	540.0	1.70
SEm±	0.01	0.04	0.09	0.46	1.7	1.7	26.3	0.07
CD (P=0.05)	0.02	0.10	0.25	1.33	4.9	4.8	76.0	0.20

Selling price of greengram seed, (₹45,000/t) in 2013–14 and (₹46,000/t) in 2014–15; selling price of stover (₹1,500/t) in 2013–14 and 2014–15; DAS, days after sowing; HW, Hand weeding; FB, followed by

Table 3. Effect of sowing date and weed management practices on nutrient uptake by crop and weeds of mungbean (pooled data of 2 years)

Treatment	Nutrient uptake by seed (kg/ha)			Nutrient uptake by stover (kg/ha)			Nutrient uptake by weed (kg/ha)		
	N	P	K	N	P	K	N	P	K
Sowing date									
June 20	31.0	5.7	14.9	26.4	2.3	30.2	30.0	9.5	22.4
July 5	30.8	5.7	14.8	25.2	2.2	28.9	35.5	13.6	27.2
July 20	29.4	5.4	14.3	24.7	2.2	28.6	43.7	20.6	34.8
SEm±	1.07	0.19	0.43	0.79	0.1	0.53	0.44	0.19	0.39
CD (P=0.05)	NS	NS	NS	NS	NS	NS	1.71	0.74	1.52
Weed management practices									
Imazethapyr 100 g/ha at 20 DAS	28.9	5.3	13.8	24.4	2.1	18.4	22.0	10.7	21.3
Mechanical weeding by finger weeder at 20 DAS	28.5	5.2	13.7	23.9	2.1	18.2	23.3	9.8	22.5
Imazethapyr 100 g/ha 20 DAS fb 1 HW at 40 DAS	38.0	7.0	18.2	30.3	2.6	23.1	9.1	2.9	6.5
Mechanical weeding by finger weeder at 20 DAS fb 1 HW at 40 DAS	35.5	6.5	17.1	28.7	2.5	21.8	10.0	6.0	8.7
HW at 20 DAS fb hoeing at 40 DAS	28.7	5.3	14.0	23.9	2.3	18.5	13.1	3.6	13.9
Weedy check	22.8	4.2	11.2	21.2	2.0	16.8	68.1	25.3	39.7
SEm±	1.4	0.25	0.56	1.18	0.1	1.19	0.81	0.33	0.48
CD (P=0.05)	4.1	0.73	1.60	3.40	0.3	3.43	2.33	0.95	1.39

N, Nitrogen; P, phosphorus; K, potassium; DAS, days after sowing; HW, Hand weeding; FB, followed by

DAS fb hoeing at 40 DAS due to higher labour wages (Kumar *et al.,* 2016).

Nutrient uptake by crop and weeds

The N, P and K uptake by both seed and stover of crop was not significantly influenced by sowing date (Table 3). However, early sowing of mungbean on June 20 recorded increased N, P and K uptake by both seed and stover of mungbean with reduced nutrient depletion by weeds as compared to delayed sowing on July 5 and July 20. All weed management practices significantly increased N, P and K uptake by mungbean (seed and stover) over weedy check. The maximum N, P and K uptake by both seed and stover was recorded with imazethapyr 100 g/ha 20 DAS fb 1 HW at 40 DAS, which was statistically at par with mechanical weeding by finger weeder at 20 DAS fb 1 HW at 40 DAS and significantly higher than rest of the treatments owing to less crop weed competition, better crop growth and grain yield.

Maximum nutrient depletion by weed was observed in delayed sowing on July 20. Significant decrease in N, P and K uptake by weeds were recorded due to all weed management practices over weedy check. Application of imazethapyr @ 100 g/ha 20 DAS fb 1 HW at 40 DAS minimized N, P and K removal by weeds to a tune of 86.6, 88.5 and 83.6% respectively over that of weedy-check influencing the weed biomass and weed-control efficiency. Similar reduction in nutrient uptake by weeds under different weed management practices had also reported by Chhodavadia *et al.* (2013) and Yadav *et al.*, (1985).

It can be concluded from the present investigation that June 20 sowing was more suitable for higher productivity and profitability in rainfed mungbean. Imazethapyr @ 100 g/ha at 20 DAS fb 1 hand weeding at 40 DAS proved remunerative and effective in crop growth, weed control, yield and nutrient uptake for timely sown mungbean under rainfed condition.

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