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Integrated Weed Management approaches in Soybean + Pigeonpea (4:2) intercropping system

Khazi GS, AS Karle and Mirza IAB

Abstract
The field investigation entitled "Integrated weed management in soybean + pigeonpea intercropping system" was conducted at experimental farm of Department of Agronomy, College of Agriculture, V.N.M.K.V., Parbhani (M.S), India during *Kharif* season of 2016-17. The experimental field was leveled and well drained. Among the weed management practices application of *PE*–Pendimethalin 30% EC @ 0.75 kg a.i./ha +1 Hoeing (30-40 DAS) + 1 Hand Weeding (40-50 DAS) recorded higher values pertaining to Yield and yield atrributes in soybean. In pigeonpea application of *PE* - Pendimethalin 30% EC @ 0.75 kg a.i./ha + *POE* – Imazethapyr 10% SL @ 0.100 kg a.i./ha + Quizalofop ethyl 10 EC @ 0.075 kg a.i./ha + 1 Hoeing (40-50 DAS) obtained higher values of yield attributes as well as yield.

Keywords: Pigeonpea, Soybean, Weed, Yield, Yield attributes.

Introduction
Soybean (*Glycine max* L.) is the only major crop that has witnessed an impressive expansion in acreage and production at the global level. Major soybean growing states in India are Madhya Pradesh, Uttar Pradesh, Maharashtra, Gujarat, Rajasthan, Karnataka and Andhra Pradesh. India rank 5th in area and production of soybean.Maharashtra ranks 2nd in terms of production of soybean after Madhya Pradesh. In India area under soybean in *Kharif* 2016 was 109.71 lakh hectares with production of 114.90 lakh tonnes. In Maharashtra soybean production during *Kharif* 2016 was 39.45 lakh metric tonnes from an area of 35.80 lakh hectares with the productivity of 1102 kg ha^{-1}. Whereas in Marathwada the area under soybean is 15.94 lakh hectares with production of 12.87 lakh tonnes and productivity is 1010 kg ha^{-1}(Source: Anonymous, SOPA 2016 production).

Pigeonpea [*Cajanus cajan* (L.)Millsp] is the fifth prominent legume crop in the world and ranked second after chickpea in India in terms of area and production. In India, the area under pigeonpea during 2016-17 was 3.86 million hectares with production of 2.90 million tonnes and average productivity of 751 kg ha^{-1}. In Maharashtra the area under pigeonpea was 1.53 million hectares with production of 1.17 million tonnes and average productivity of 764 kg ha^{-1} and in Marathwada the area is 5.3 lakh hectares with production of 1.3 lakh tonnes (Anonymous, 2016). When pigeonpea is grown as a sole crop, it is relatively inefficient because of its slow initial growth rate and low harvest index (Willey, 1979); therefore it is grown as intercrop, which helps in efficient utilization of available resources for enhancing the productivity and profitability.

Intercropping is the agricultural practice of growing two or more crops simultaneously on the same field with definite row proportion. Weed suppression, the reduction of weed growth by crop interference, has been referred as one determinant of yield advantage of intercropping. Hence intercropping is an option for an Integrated Weed Management (IWM), particularly in farming systems with low external inputs. Currently, there is renewed interest in India in intercropping because resources may be used more efficiently than in the corresponding monoculture and because of these we can lead towards sustainability.Based on the per cent of plant population used for each crop in intercropping system, it is divided into two types*viz.* Additive and replacement series. Soybean + pigeonpea (4:2) are one of the example of intercropping in replacement series (Kasbe *et al*. 2010).

Materials and Methods
The field investigation entitled "Integrated weed management in soybean + pigeonpea intercropping system" was conducted at experimental farm of Department of Agronomy, College of Agriculture, V.N.M.K.V., Parbhani (M.S), India during *Kharif*, 2016-17. The experimental field was leveled and well drained. The soil was clayey in texture, low in available nitrogen, medium in phosphorus, high in potassium and slightly alkaline in reaction.

The environmental conditions prevailed during research period was favorable for normal growth and maturity of soybean and pigeonpea crop. The experiment was laid down in randomized block design. The present investigation consists of 10 weed management treatments. Treatments were: T_1- *PE*- Pendimethalin 30% EC @ 1.0 kg a.i./ha, T_2- *PE*–Pendimethalin 30% EC @ 0.75 kg a.i./ha +1 Hoeing (30-40 DAS) + 1 Hand Weeding (40-50 DAS), T_3- *PE*-Pendimethalin 30% EC @ 0.75 kg a.i./ha +*POE* – Imazethapyr 35% + Imazamox 35% WG @ 0.01 kg a.i /ha + 1 Hoeing (40-50 DAS) T_4- *PE* - Pendimethalin 30% EC @ 0.75 kg a.i./ha + *POE* – Imazethapyr 10% SL @ 0.100 kg a.i./ha + Quizalofop ethyl 10 EC @ 0.075 kg a.i./ha + 1 Hoeing (40-50 DAS), T_5- Stale seed bed technique + 1 hoeing (25-30 DAS) + mulching (30 DAS), T_6 - Stale seed bed technique + 1 hoeing (25-30 DAS) + 1 Hand Weeding (40-50 DAS), T_7- Stale seed bed technique + *POE*-Imazethapyr35% + Imazamox 35% WG @ 0.01 kg a.i./ha, T_8- Stale seed bed technique + *POE*-Imazethapyr 10% SL @ 0.100 kg a.i./ha + Quizalofop ethyl 10 EC @ 0.075 kg a.i. /ha, T_9 - Weed free, T_{10} – Weedy check. The gross and net plot size of each experimental unit was 6.1 m x 6.0 m and 3.6 m x 5.0 m respectively. The recommended cultural practices and plant protection measures were followed. Application of fertilizer was carried out at the time of sowing. The experimental data obtained on various selected variables were analyzed by the standard method of statistical analysis (Panse and Sukhatme, 1967) for randomized block design.

Results and Discussion

a) Soybean

Treatment of weed free (T_9) recorded significantly higher, number of pods plant^{-1}, weight of pods plant^{-1}, weight of seeds plant^{-1}, number of seeds pod^{-1}, test weight, indicating least competition offered by weeds for nutrients and moisture at crucial growth stages under this treatment ultimately improved all yield attributes besides increased rate of N, P and K absorption cumulatively helped the crop plants to produce more surface area for high photosynthetic rate as well as maximum translocation of photosynthesis from source to sink, subsequently resulted in improvement of all yield attributes. Because of synergist effect among the yield attributes they benefited each other. These findings are in accordance with those of Meena *et al.* (2012).

Seed yield was a function of yield attributes. Similarly, biological yield of crop plant has a close relationship with its economical yield. Data presented in (Table3) reported that the per hectare seed yield of soybean were appreciably higher in all the weed control treatments as compared to weedy check (T_{10}). Weed free treatment recorded significantly higher seed yield but remained statistically at par with the application of *PE*–Pendimethalin 30% EC @ 0.75 kg a.i./ha **+** 1 Hoeing (30-40 DAS) +1 Hand Weeding (40-50 DAS). This might be due to higher seed yield plant^{-1} which occurred from increased pod number, pod weight plant^{-1} and number of seeds plant^{-1}.Among different weed management practices, significantly the maximum seed yield was recorded under T_2 followed by T_8. While the lowest number of pods plant^{-1}, weight of pods plant^{-1}, weight of seeds plant^{-1}, number of seeds pod^{-1}, test weight, seed yield (kg ha^{-1}), straw yield (kg ha^{-1}) and harvest index (%) were recorded in weedy check (T_{10}) in pooled results due to higher weed density (Singh *et al.* 2016). Harvest index was recorded minimum in unweeded control because of poor partitioning of photosynthesis source to sink (Sangeetha *et al*. 2012). This might be due to higher seed yield plant^{-1} which occurred from increased pod number, pod weight plant^{-1} and number of seeds plant^{-1}.

The yield is a cumulative effect of different growth and yield attributing characters. Whereas, straw yield was an augmenting effect of increased vegetative growth through plant height, number of branches and number of leaves plant^{-1}. Profound effect on seed yield ha^{-1} was noted due to different weed management practices. The yield reflected in these treatments showed the effectiveness to control the weeds at important growth stages as well as higher uptake of nutrients. Different herbicides with divergent chemical composition along with cultural or integrated practices were found to control weeds in soybean to a varying degree. This can be seen not only from the effect of herbicides on weeds but also from the crop yields. Many research workers reviewed the comparative performance of herbicides in respect to higher soybean production *viz*. Dhaker *et al.* (2016), and Sharma *et al.*(2017).

b) Pigeonpea

The various yield components were significantly influenced by different weed control treatments. Weed free plot recorded maximum number of pods plant^{-1}, higher seed yield plant^{-1} and higher thousand seed weight. The higher yield components in weed free plot was mainly due to the complete elimination of weeds throughout the crop growth, which enabled the better plant growth along with more primary and secondary branches and leaf area, which resulted in higher yield attributing parameters. Whereas these yield components were adversely affected in weedy check. This is due to heavy weed infestation and more crop-weed competition. Among the herbicidal treatments, higher number of pods plant^{-1}, higher number of seeds pod^{-1}and seed yield plant^{-1}was observed in *PE* - Pendimethalin 30% EC @ 0.75 kg a.i./ha + *POE* - Imazethapyr 10% SL @ 0.100 kg a.i./ha + Quizalofop ethyl 10 EC @ 0.075 kg a.i./ha + 1 Hoeing (40-50 DAS) followed by *PE*- Pendimethalin 30% EC @ 0.75 kg a.i./ha +*POE* – Imazethapyr 35% + Imazamox 35% WG @ 0.01 kg a.i /ha **+** 1 Hoeing (40-50 DAS). The higher yield attributes were obtained may be due to higher weed control efficiency. Pradhan*et al.* (2010) also reported higher weed control efficiency (93%) in Imazethapyr @ 25 g ha^{-1} at 20 DAS.

Seed yield differed significantly owing to different weed control treatments. Significantly higher seed yield was recorded in weed free plot. The higher yield in weed free plot was mainly due to the complete elimination of weeds throughout the crop growth which enabled minimum competition and causing better plant growth along with more primary and secondary branches. Higher seed yield was also due to higher nutrient uptake by pigeonpea that resulted in higher seed yield. Among the herbicidal treatments *PE* - Pendimethalin 30% EC @ 0.75 kg a.i./ha + *POE* - Imazethapyr 10% SL @ 0.100 kg a.i./ha + Quizalofop ethyl 10 EC @ 0.075 kg a.i./ha + 1 Hoeing (40-50 DAS) recorded higher seed yield and straw yield. Further, the higher yields in these treatments could be attributed to higher dry matter accumulation per plant, plant height, higher nutrient uptake and selective nature of herbicide during early growth stage of the crop. Further higher yield was also due to higher weed control efficiency and minimized crop-weed competition during crop growth. Thus crop plants might have used available resources effectively throughout the crop growth stages resulting in higher seed yield. These results are in close confirmation with the findings of Padmaja *et al.* (2013).They reported that application of Imazethapyr recorded higher yield attributes and yield which was due to lower weed density and weed dry weight. Application of herbicides controlled the weeds effectively and made available nutrients to crop and consequently resulted in higher yield (Channappagoudar and Biradar 2007). While, weedy check recorded lower yield due to heavy weed infestation and more crop weed competition throughout the crop growth resulting in low nutrient uptake by crop. While weeds removed more quantity of nutrients throughout the crop growth period. This shows that the reduction in yield was apparently due to reduction in growth and yield components caused by weed infestation. These results are in close conformity with the findings of Semwal *et al.*(2016), Vinutha and Patil (2016).

c) Weed control efficiency and weed index

Weed control efficiency represents efficiency of weed control treatments compared to weedy check. The highest weed control efficiency was recorded in weed free treatment *i.e.* 68.23 per cent 2016-17, respectively. Whereas in weed management practices higher weed control efficiency was observed with the application of *PE* - Pendimethalin 30% EC @ 0.75 kg a.i./ha + *POE* - Imazethapyr 10% SL @ 0.100 kg a.i./ha + Quizalofop ethyl 10 EC @ 0.075 kg a.i./ha + 1 Hoeing (40-50 DAS) 60.98 per cent and followed by treatment *PE*- Pendimethalin 30% EC @ 0.75 kg a.i./ha +*POE* – Imazethapyr 35% + Imazamox 35% WG @ 0.01 kg a.i /ha **+** 1 Hoeing (40-50 DAS) 59.07 percent. This might be due to effective weed control achieved under efficient method of weed management in term of reduced biomass of weeds and higher weed control efficiency.

Looking to weed index which is the indicator of losses in seed yield due to presence of weeds was the lowest under treatment *PE*–Pendimethalin 30% EC @ 0.75 kg a.i./ha **+** 1 Hoeing (30-40 DAS) +1 Hand Weeding (40-50 DAS) 12.74 per cent and followed by treatment *PE* - Pendimethalin 30% EC @ 0.75 kg a.i./ha + *POE* - Imazethapyr 10% SL @ 0.100 kg a.i./ha + Quizalofop ethyl 10 EC @ 0.075 kg a.i./ha + 1 Hoeing (40-50 DAS) 21.45 per cent indicating gain in higher seed yield production and monetary returns. Highest weed index was recorded by weedy check (60.84 per cent) which indicated the highest seed yield loss recorded by the treatment. Almost similar results were also reported by Nepalia *et al.* (2017) with respect to weed population, weed dry weight and weed control efficiency.

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