



Efficacy of herbicides and nutrient management on weed dynamics and yield of French bean (*Phaseolus vulgaris*)

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ABSTRACT

A field experiment was conducted to assess the effect of herbicides and integrated nutrient managements on weed dynamics, NPK removal and yield of French bean (*Phaseolus vulgaris* L.) at Banaras Hindu University, Varanasi during 2009 and 2010. The results revealed that the pendimethalin fb quizalofop-p-ethyl had significantly marked potential to minimize the weed dynamics of *Chenopodium album*, *Melilotus alba*, *Melilotus indica* and *Cyperus rotundus* significantly, resulted in marked reduction on total weed density (41.48 and 41.11 nos/m), weed dry weight (45.62 and 44.68 g/m) and weed index at all stages of crop growth during 2009 and 2010, respectively and showed higher weed control efficiency over the alone application of pendimethalin. Recommended dose + 200 kg Wellgro Soil (Dust) minimized broad leaves weeds (BLWs) over rest of the fertility levels but at par with RD + 300 kg Wellgro Soil (Dust) in respect of BLWs weed density that resulted in enhanced weed index due to higher weed control efficiency over rest of the fertility levels during both the years of study. Significantly lower NPK removal by weeds at harvest recorded with pendimethalin fb quizalofop-p-ethyl under recommended dose + 200 kg Wellgro Soil (Dust), though remained at par with recommended dose + 300 kg Wellgro Soil (Dust).

Key words: Integrated nutrient management, WCE, Weed density, Weed dry weight, Weed management, WI, Yield

French bean (*Phaseolus vulgaris* L.) commonly known as rajmash is an important pulse crop with 22.9% grain protein, 60.6% carbohydrates, 1.3% fat besides 381 mg calcium, 42.5 mg phosphorus and 12.4 mg iron per 100 g of edible parts. Globally, being one of the premier crops, it occupies 28.2 million ha area with an annual production of 18.95 million tonnes. Amongst the French bean producing countries, Brazil ranks first in area and production. Other important French bean producing countries are Angola, Burundi, Cameroon, Rwanda, Tanzania, Uganda and Zaire in Africa; Mexico, USA and Canada in North America; Colombia in South America and Turkey, China and India in Asia. In India, traditionally, it is cultivated in the hilly tracts of Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh, Bihar, Odisha and some parts of Maharashtra (Mahabaleshwar and Ratnagiri regions) in about 98000 ha area with 1000 tonnes production as a *kharif* season crop. Due to its specific adoption to cool and long growing season prevailing in the region (Kushwaha, 1994). In the north eastern plains, French bean has been introduced as a nontraditional rabi grain legume and has provided the

opportunity to farmers to grow pulses under high input management conditions. In addition, the rajmash protein proved a quality protein for human consumption in the manner the soybean oil proved its worth. Rajmash is a high productive and input responsible crop suitable for intensive cropping system. The crop has been successfully introduced in northern plains by developing suitable varieties. Rajmash has a great potential and can contribute substantially to foreign exchange. The major bottleneck is the marketing which needs to be strengthened. The use of Wellgro – soil, a neem cake based organic manure with low C/N ratio (10-16:1), contains 1.6 - 2.6 % N, 0.25 – 1.12 % P, 0.89 - 1.47 % K and improves soil fertility by supplying of organic nutrients and amino acids. It improves moisture retention capacity of the soil, chemical fertilizer use efficiency and tolerance to soil-borne pests. Wellgro is a plant product formulation in grain and powder forms produced by an Indian Tobacco Company (ITC). Hence, in the present investigation the effect of different doses of herbicide application and recommended dose of fertilizer with wellgro formulation on growth and development in French bean was studied. Obviously, an interaction of eco – ameliorating neem based organic inclusion in fertilizer alongwith herbicide regulation (pre and post emergence) is expected in furthering the cause of a more scientific production of French bean with better yield and quality.

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MATERIALS AND METHODS

A field experiment was carried out during *rabi* 2009 and 2010 at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India (25°18' N latitude; 83°03' E longitude; altitude 75.7 m amsl) in Northern Gangetic alluvial plains having sub

tropical climate. The soil of experimental plot was sandy-clay-loam (48.6 % sand, silt 26.1% and clay 25.1%) with low in organic carbon (0.42% and 0.44 %) and nitrogen (208.3 and 214.5 kg/ha), but medium in phosphorus (19.4 and 20.3 kg/ha), potassium (214.3 and 228.5 kg/ha) pH (7.6 and 7.5) and EC (0.97 and 0.93) during both the years of experiment before transplanting, respectively.

Table 1 Chemical composition of the Wellgro soil (dust)

| Chemical composition | Range | Minimum |
|--|-------------|-----------|
| Total organic carbon | 20%-25% | 20% |
| Total nitrogen (as N) | 1.6%-2.6% | 1.60% |
| C/N ratio | 10-16:1 | 10:1 |
| Phosphorus (as P ₂ O ₅) | 0.25%-1.12% | 0.25% |
| Potash (as K ₂ O) | 0.89%-1.47% | 0.89% |
| Bulk density | 0.71 g/ml | 0.71 g/ml |
| Colour | Brown | Brown |
| Moisture | 9%-10% | 10% |

Heavy metals (Arsenic, cadmium etc) are less than tolerance limits

The experiment was laid-out in three time replicated split-plot design. Five weed management practices, Quizalofop-ethyl@ 50 g a.i./ha at 20 DAS (Post-emergence), Pendimethalin@ 1.0 kg/ha (per-emergence), Pendimethalin@ 1.0 kg/ha (per-emergence) fb quizalofop-ethyl@ 50 g a.i./ha at 20 DAS (Post-emergence), Weedy check, 2HW (20+40 DAS) were assigned to main plot. Five different fertility levels recommended dose (120 kg N, 60 kg P, 40 kg K and 20 kg S), recommended dose +200 kg/ha Wellgro soil (dust), recommended dose +300 kg/ha Wellgro soil (dust), 75% recommended dose +200 kg/ha Wellgro soil (dust) and 75% RD+300 kg/ha Wellgro soil (dust) were allocated to sub plots.

Plot size was kept 5 × 3 m² and the net plot size was

Table 2 Effect of herbicides and integrated nutrient management on weed count/m² (*Chenopodium album*) at different stages of French bean

| Treatment | 30 DAS | | 60 DAS | | 90 DAS | | At harvest | |
|--|------------------|-----------------|-----------------|-----------------|-------------------|-------------------|-------------------|-------------------|
| | 2009-10 | 2010-11 | 2009-10 | 2010-11 | 2009-10 | 2010-11 | 2009-10 | 2010-11 |
| <i>Herbicide application</i> | | | | | | | | |
| W1 - Quizalofop-p-ethyl 50 g/ha at 20 DAS | 5.42 (28.85)* | 5.31 (27.76) | 5.82 (33.43) | 5.63 (31.27) | 10.04 (100.30) | 9.65 (92.60) | 9.56 (90.96) | 9.52 (90.23) |
| W2 - Pendimethalin 1.0 kg/ha | 4.02 (15.71) | 3.88 (14.62) | 4.56 (20.30) | 4.26 (17.67) | 7.83 (60.89) | 7.44 (54.93) | 7.33 (53.30) | 7.27 (52.46) |
| W3 - Pendimethalin 1.0 kg/ha fb quizalofop-p-ethyl 50 g/ha at 20 DAS | 3.01 (8.65) | 2.82 (7.56) | 3.70 (13.23) | 3.62 (12.63) | 6.33 (39.70) | 6.19 (37.88) | 6.05 (36.25) | 5.98 (35.34) |
| W4 - Weedy check | 6.21 (38.09) | 6.12 (37.00) | 6.57 (42.68) | 6.46 (40.80) | 11.27 (126.77) | 11.16 (124.01) | 11.04 (121.51) | 10.63 (112.62) |
| W5 - 2 HW (20+40 DAS) | 2.05 (3.81) | 1.74 (2.69) | 2.95 (8.26) | 2.79 (7.32) | 5.00 (24.58) | 4.67 (21.42) | 4.50 (19.79) | 4.23 (17.48) |
| SEm ± | 0.07 | 0.08 | 0.06 | 0.02 | 0.14 | 0.06 | 0.08 | 0.07 |
| CD (P = 0.05) | 0.21 | 0.26 | 0.18 | 0.08 | 0.44 | 0.18 | 0.25 | 0.24 |
| <i>Fertilizer level</i> | | | | | | | | |
| F1 - RD (N120 P60 K40 S20) | 4.36 (20.76) | 4.21 (19.67) | 4.91 (25.34) | 4.67 (22.77) | 8.37 (74.96) | 8.02 (69.19) | 7.88 (67.02) | 7.72 (64.22) |
| F2- RD + 200 kg/ha Wellgro soil (dust) | 4.05 (18.29) | 3.87 (17.17) | 4.63 (22.81) | 4.49 (21.52) | 7.97 (68.42) | 7.71 (64.69) | 7.59 (62.92) | 7.40 (60.16) |
| F3 - RD + 300 kg/ha-Wellgro soil (dust) | 3.91 (17.25) | 3.73 (16.16) | 4.52 (21.77) | 4.40 (20.74) | 7.76 (65.19) | 7.56 (62.55) | 7.43 (60.72) | 7.26 (58.19) |
| F4 - 75% RD + 200 kg/ha Wellgro soil (dust) | 4.25 (19.83) | 4.09 (18.74) | 4.81 (24.42) | 4.61 (22.48) | 8.26 (72.99) | 7.93 (67.59) | 7.82 (65.95) | 7.67 (63.36) |
| F5 - 75% RD + 300 kg/ha Wellgro soil (dust) | 4.14 (18.97) | 3.98 (17.88) | 4.72 (23.56) | 4.58 (22.16) | 8.11 (70.68) | 7.88 (66.82) | 7.77 (65.19) | 7.58 (62.19) |
| SEm ± | 0.04 | 0.05 | 0.03 | 0.03 | 0.07 | 0.05 | 0.07 | 0.06 |
| CD (P = 0.05) | 0.11 | 0.14 | 0.10 | 0.07 | 0.19 | 0.13 | 0.20 | 0.18 |

*Figures in parentheses are the original values

4 × 2.4 m² with the block and plot border 1 m each. The test crop variety HUR-137 was grown having same set of treatments and the whole setup was repeated during the second year to confirm the results. For weed management, herbicides (pre and post-emergence) and HW was applied as per treatments. Species-wise weed density (No./m²) and weed dry weight (g/m²) at 30, 60, 90 DAS, and at harvest and yield were observed. Weed control efficiency (%) and weed index were determined using standard procedures. All the data were statistically analysed to draw a valid conclusions. The sources of inorganic fertilizers were Urea, DAP, MOP and SSP and Wellgro soil. As per treatment, full dose of nitrogen, phosphorus, potassium, SSP and Wellgro soil were applied as basal (just before sowing of the crop).

Weed control efficiency (WCE) was calculated by using the following formula suggested by Mani *et al.* (1973):

$$\text{WCE (\%)} = \frac{\text{DMC} - \text{DMT}}{\text{DMC}} \times 100$$

where, DMC = Dry matter production of weeds/m² in weedy check. DMT = Dry matter production of weeds/m² in the treatment to be compared. WCE was expressed in percentage.

Weed index is per cent reduction in grain yield due to weeds as compared total yield of weed free treatment. The weed index was calculated by using the formula as followed:

$$\text{WI (\%)} = \frac{\text{X} - \text{Y}}{\text{X}} \times 100$$

where, X = Grain yield from weed free plot, Y = Grain yield from treatment for which weed index is to be worked out.

Weed index are expressed in percentage.

RESULTS AND DISCUSSION

Weed density

Among the weed management treatments significantly less weed population of *Chenopodium album*, *Melilotus indica*, *Melilotus alba* and *Cyperus rotundus* were recorded with the application of pendimethalin@ 1.0 kg/ha fb quizalofop-p-ethyl@ 50 g a.i/ha at 20 DAS than pendimethalin@ 1.0 kg/ha at all growth stages during both the years of experimentation (Table 2, 3, 4, 5). The higher dose of herbicides provided significantly better control when applied alone or combination. However, significantly higher population of weeds was found associated with weedy check as compared to other treatments. These results are in close conformity with the findings of Soltani *et al.* (2012).

Data further revealed that total weed density considerably reduced due to application of different weed management. Significantly higher reduction in weed population of

Table 3 Effect of herbicides and integrated nutrient management on weed count/m (*Melilotus indica*) at different stages of French bean

| Treatment | 30 DAS | | 60 DAS | | 90 DAS | | At harvest | |
|--|-------------|------------|------------|------------|------------|------------|------------|------------|
| | 2009-10 | 2010-11 | 2009-10 | 2010-11 | 2009-10 | 2010-11 | 2009-10 | 2010-11 |
| <i>Herbicide application</i> | | | | | | | | |
| W1 - Quizalofop-p-ethyl 50 g/ha at 20 DAS | 1.04(0.58)* | 1.02(0.53) | 1.46(1.64) | 1.42(1.53) | 1.59(2.02) | 1.56(1.94) | 1.57(1.95) | 1.53(1.85) |
| W2 - Pendimethalin 1.0 kg/ha | 0.97(0.43) | 0.94(0.38) | 1.39(1.43) | 1.36(1.34) | 1.50(1.76) | 1.48(1.70) | 1.49(1.72) | 1.46(1.64) |
| W3 - Pendimethalin 1.0 kg/ha fb quizalofop-p-ethyl 50 g/ha at 20 DAS | 0.89(0.30) | 0.86(0.24) | 1.31(1.22) | 1.28(1.13) | 1.42(1.52) | 1.39(1.43) | 1.40(1.47) | 1.38(1.41) |
| W4 - Weedy check | 1.14(0.81) | 1.11(0.73) | 1.56(1.94) | 1.51(1.79) | 1.79(2.71) | 1.71(2.42) | 1.74(2.54) | 1.70(2.40) |
| W5 - 2HW (20+40 DAS) | 0.82(0.17) | 0.79(0.12) | 1.21(0.97) | 1.18(0.89) | 1.33(1.26) | 1.29(1.17) | 1.31(1.21) | 1.27(1.13) |
| SEm ± | 0.002 | 0.006 | 0.003 | 0.006 | 0.004 | 0.008 | 0.005 | 0.009 |
| CD (P = 0.05) | 0.007 | 0.019 | 0.010 | 0.021 | 0.014 | 0.026 | 0.015 | 0.031 |
| <i>Fertilizer level</i> | | | | | | | | |
| F1 - RD (N120 P60 K40 S20) | 1.00(0.52) | 0.98(0.47) | 1.42(1.53) | 1.38(1.43) | 1.57(1.99) | 1.52(1.85) | 1.54(1.89) | 1.51(1.80) |
| F2- RD + 200 kg/ha Wellgro soil (dust) | 0.96(0.43) | 0.93(0.37) | 1.37(1.40) | 1.34(1.30) | 1.51(1.80) | 1.47(1.67) | 1.49(1.74) | 1.46(1.65) |
| F3 - RD + 300 kg/ha Wellgro soil (dust) | 0.94(0.40) | 0.91(0.34) | 1.36(1.35) | 1.31(1.23) | 1.49(1.75) | 1.44(1.60) | 1.46(1.65) | 1.42(1.52) |
| F4 - 75% RD + 200 kg/ha Wellgro soil (dust) | 0.99(0.49) | 0.96(0.44) | 1.40(1.48) | 1.37(1.40) | 1.54(1.89) | 1.51(1.80) | 1.52(1.83) | 1.49(1.76) |
| F5 - 75% RD + 300 kg/ha Wellgro soil (dust) | 0.97(0.46) | 0.94(0.39) | 1.39(1.44) | 1.35(1.33) | 1.52(1.84) | 1.49(1.74) | 1.50(1.79) | 1.48(1.71) |
| SEm ± | 0.002 | 0.005 | 0.002 | 0.004 | 0.003 | 0.006 | 0.004 | 0.008 |
| CD (P= 0.05) | 0.006 | 0.015 | 0.005 | 0.012 | 0.008 | 0.018 | 0.011 | 0.022 |

*Figures in parentheses are the original values

Table 4 Effect of herbicides and integrated nutrient management on weed count/m² (*Melilotus alba*) at different stages of French bean

| Treatment | 30 DAS | | 60 DAS | | 90 DAS | | At harvest | |
|---|-------------|------------|------------|------------|------------|------------|------------|------------|
| | 2009-10 | 2010-11 | 2009-10 | 2010-11 | 2009-10 | 2010-11 | 2009-10 | 2010-11 |
| <i>Herbicide application</i> | | | | | | | | |
| W1 - Quizalofop-p-ethyl 50g/ha at 20 DAS | 1.24(1.03)* | 1.20(0.95) | 1.32(1.24) | 1.30(1.19) | 1.50(1.75) | 1.48(1.68) | 1.49(1.72) | 1.48(1.69) |
| W2 - Pendimethalin 1.0 kg/ ha | 1.15(0.83) | 1.12(0.76) | 1.21(0.97) | 1.18(0.89) | 1.41(1.49) | 1.39(1.43) | 1.40(1.47) | 1.38(1.41) |
| W3- Pendimethalin 1.0 kg/ha fb Quizalofop- p- ethyl@ 50 g a.i./ha at 20 DAS | 1.05(0.60) | 1.02(0.54) | 1.11(0.73) | 1.08(0.67) | 1.32(1.25) | 1.30(1.20) | 1.31(1.22) | 1.30(1.19) |
| W4 - Weedy check | 1.29(1.26) | 1.27(1.13) | 1.45(1.60) | 1.41(1.49) | 1.59(2.04) | 1.56(1.93) | 1.58(1.98) | 1.55(1.89) |
| W5 - 2 HW (20+40 DAS) | 0.86(0.24) | 0.81(0.15) | 1.03(0.57) | 0.98(0.47) | 1.23(1.01) | 1.19(0.92) | 1.22(0.98) | 1.17(0.88) |
| SEm ± | 0.01 | 0.01 | 0.01 | 0.01 | 0.005 | 0.005 | 0.002 | 0.006 |
| CD (P = 0.05) | 0.04 | 0.02 | 0.03 | 0.02 | 0.016 | 0.017 | 0.006 | 0.019 |
| <i>Fertilizer level</i> | | | | | | | | |
| F1 - RD (N120 P60 K40 S20) | 1.17(0.88) | 1.12(0.78) | 1.27(1.13) | 1.24(1.08) | 1.45(1.62) | 1.42(1.53) | 1.44(1.58) | 1.42(1.53) |
| F2 – RD + 200 kg/ha Wellgro soil (dust) | 1.10(0.75) | 1.07(0.68) | 1.20(0.96) | 1.16(0.87) | 1.39(1.45) | 1.37(1.39) | 1.38(1.42) | 1.35(1.35) |
| F3 - RD + 300 kg/ha Wellgro soil (dust) | 1.05(0.71) | 1.04(0.62) | 1.19(0.93) | 1.14(0.83) | 1.37(1.40) | 1.34(1.32) | 1.36(1.37) | 1.33(1.29) |
| F4 - 75% RD + 200 kg/ha Wellgro soil (dust) | 1.15(0.84) | 1.10(0.74) | 1.24(1.06) | 1.22(1.00) | 1.43(1.56) | 1.40(1.49) | 1.42(1.53) | 1.40(1.48) |
| F5 - 75% RD + 300 kg/ha Wellgro soil (dust) | 1.12(0.79) | 1.09(0.71) | 1.22(1.02) | 1.19(0.93) | 1.41(1.50) | 1.39(1.43) | 1.40(1.47) | 1.38(0) |
| SEm ± | 0.01 | 0.01 | 0.00 | 0.01 | 0.001 | 0.004 | 0.002 | 0.004 |
| CD (P = 0.05) | 0.04 | 0.02 | 0.01 | 0.01 | 0.004 | 0.010 | 0.005 | 0.011 |

*Figures in parentheses are the original values

Chenopodium album, *Melilotus indica*, *Melilotus alba* and *Cyperus rotundus* by different levels of fertilizers. It was noticed that Recommended Dose + 300 kg/ha Wellgro soil (dust) recorded higher reduction in density of *Chenopodium album*, *Melilotus indica*, *Melilotus alba* and *Cyperus rotundus* as compared to rest of the treatments except recommended dose + 200 kg/ha Wellgro soil (dust) where it was at par with each other. The treatment 75% recommended dose + 300 kg/ha Wellgro soil (dust) and 75% recommended dose + 200 kg/ha Wellgro soil (dust) was at par with each other, but significantly superior to recommended dose of fertilizers with respect to density. This was might be due to vigorous growth of plant under both the treatments coincided with shading effect on weed resulted into etiolated weed. The results are in conformity with the finding of Prajapati *et al.* (2003).

Weed dry weight

Dry matter accumulation in weeds significantly influenced by weed management. Pendimethalin @1 kg a.i./ha markedly decreased the total weed dry weight (TWDW), i.e 5.11 and 4.55, 40.16 and 37.82, 55.82 and 54.05, and 53.80 and 53.05 g/m² as compared to pendimethalin at 30,60,90 and at harvest during 2009 and 2010, respectively (Table 6). However, maximum weed dry weight was

recorded under weedy check, this might be due to its lower efficiency for control of weeds during both the years of observations. Cotyledon of weeds when come in contact with pre-emergence herbicide during germination which able to stopping weed emergence above ground growth, however latter ontogenic flushes minimized due to post-emergence application of herbicides resulted in lower weed density per unit area and recorded lesser weed dry weight ultimately. Similar results were also reported by Prajapati *et al.* (2004).

Among, the fertility levels TWDW at different stages of *Chenopodium album*, *Melilotus indica*, *Melilotus alba* and *Cyperus rotundus* revealed significant reduction in its population, resulted in lower TWDW at different stages by different levels of fertilizers. It was noticed that recommended dose + 300 kg/ha Wellgro soil (dust) recorded higher reduction in TWDW of *Chenopodium album*, *Melilotus indica*, *Melilotus alba* and *Cyperus rotundus* as compared to rest of the treatments except recommended dose +200 kg/ha Wellgro soil (dust) where it was at par with each other. Thereafter, 75% recommended dose + 300 kg/ha Wellgro soil (dust) and 75% recommended dose +200 kg/ha Wellgro soil (dust) removed at par with each other, but significantly superior to recommended dose of fertilizers with respect to TWDW (Sharma *et al.* 2009).

Table 5 Effect of herbicides and integrated nutrient management on weed count/m³ (*Cyperus rotundus*) at different stages of French bean

| Treatment | 30 DAS | | 60 DAS | | 90 DAS | | At harvest | |
|--|-----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| | 2009-10 | 2010-11 | 2009-10 | 2010-11 | 2009-10 | 2010-11 | 2009-10 | 2010-11 |
| <i>Herbicide application</i> | | | | | | | | |
| W1 - Quizalofop-p-ethyl 50g/ha at 20 DAS | 1.17 (0.88)* | 1.15 (0.83) | 1.71 (2.45) | 1.46 (1.62) | 1.86 (2.96) | 1.83 (2.87) | 1.83 (2.83) | 1.82 (2.82) |
| W2 - Pendimethalin 1.0 kg/ha | 1.08 (0.67) | 1.06 (0.63) | 1.47 (1.68) | 1.36 (1.36) | 1.81 (2.78) | 1.79 (2.70) | 1.80 (2.74) | 1.77 (2.63) |
| W3- Pendimethalin 1.0 kg/ha fb Quizalofop- p- ethyl@ 50 g a.i./ha at 20 DAS | 0.95 (0.39) | 0.92 (0.35) | 1.29 (1.16) | 1.22 (1.00) | 1.76 (2.60) | 1.67 (2.32) | 1.74 (2.54) | 1.72 (2.45) |
| W4 - Weedy check | 1.26 (1.09) | 1.24 (1.04) | 1.88 (3.04) | 1.55 (1.90) | 1.94 (3.26) | 1.91 (3.17) | 1.92 (3.20) | 1.86 (2.96) |
| W5 - 2 HW (20+40 DAS) | 0.80 (0.14) | 0.79 (0.13) | 1.15 (0.82) | 1.04 (0.59) | 1.68 (2.31) | 1.54 (1.91) | 1.62 (2.15) | 1.59 (2.04) |
| SEm ± | 0.003 | 0.007 | 0.015 | 0.004 | 0.002 | 0.040 | 0.013 | 0.014 |
| CD (P = 0.05) | 0.011 | 0.022 | 0.050 | 0.012 | 0.008 | 0.130 | 0.042 | 0.045 |
| <i>Fertilizer level</i> | | | | | | | | |
| F1 - RD (N120 P60 K40 S20) | 1.09 (0.72) | 1.08 (0.69) | 1.57 (2.04) | 1.37 (1.41) | 1.84 (2.88) | 1.80 (2.75) | 1.82 (2.80) | 1.78 (2.69) |
| F2 – RD + 200 kg/ha Wellgro soil (dust) | 1.04 (0.61) | 1.01 (0.55) | 1.46 (1.71) | 1.30 (1.24) | 1.80 (2.74) | 1.73 (2.52) | 1.78 (2.67) | 1.75 (2.56) |
| F3 - RD + 300 kg/ha Wellgro soil (dust) | 1.01 (0.55) | 0.99 (0.51) | 1.43 (1.61) | 1.27 (1.16) | 1.78 (2.67) | 1.70 (2.42) | 1.73 (2.52) | 1.70 (2.41) |
| F4 - 75% RD + 200 kg/ha Wellgro soil (dust) | 1.07 (0.67) | 1.05 (0.63) | 1.54 (1.94) | 1.35 (1.35) | 1.82 (2.84) | 1.78 (2.69) | 1.80 (2.76) | 1.77 (2.65) |
| F5 - 75% RD + 300 kg/ha Wellgro soil (dust) | 1.05 (0.63) | 1.03 (0.60) | 1.51 (1.85) | 1.33 (1.31) | 1.81 (2.79) | 1.74 (2.57) | 1.79 (2.71) | 1.76 (2.59) |
| SEm ± | 0.002 | 0.006 | 0.014 | 0.003 | 0.001 | 0.024 | 0.010 | 0.011 |
| CD (P = 0.05) | 0.006 | 0.017 | 0.041 | 0.009 | 0.004 | 0.067 | 0.030 | 0.031 |

*Figures in parentheses are the original values

Weed control efficiency and weed index

Data revealed that pendimethalin@ 1.0 kg/ha fb quizalofop-p-ethyl@ 50 g a.i./ha at 20 DAS brought higher weed control efficiency (72.25 and 72.54%) and lower weed index (7.46 and 5.54 %) during both the year of investigations than over pendimethalin @ 1.0 a.i. kg/ha at harvest during 2009 and 2010, respectively during both the years of experimentation (Table 6). The WI markedly decreased due to lower infestation of weeds and an indicative of higher efficacy of the treatments for improving WCE and caused higher grain yield. These results are in close conformity with the findings of Grafstrom *et al.* (1982).

Fertility levels also played important role in controlling weeds due to dry matter of weeds reduced under higher level of nutrients. Application of recommended dose +200 kg/ha Wellgro soil (dust) recorded the highest WCE and lowest WI during both the years of investigation (Singh *et al.* 2001).

Grain yield

The significantly higher yield (1848 and 1960 kg/ha) was produced with the application of pendimethalin @ 1.0 a.i. kg/ha fb quizalofop-p-ethyl@ 50 g a.i./ha at 20 DAS and also significant over rest of the treatments during 2009

and 2010 (Table 7). Similar results were also reported by Jahanbakhshi and Saeedipour (2015).

Similarly, application of recommended dose +200 kg/ha Wellgro soil (dust) resulted in significant superiority over rest of the fertility levels with respect to yield. However, application of 75% recommended dose +300 kg/ha Wellgro soil (dust) remained at par with 75% recommended dose +200 kg/ha Wellgro soil (dust) with regard to yield during both the year of investigation. The significantly higher grain yield (1746 and 1817 kg/ha) were recorded by recommended dose + 200 kg/ha Wellgro soil (dust), whereas straw yield was highest recommended dose + 300 kg/ha Wellgro soil (dust), but both the treatments were at par with each other. Similar findings were also reported by Sharma *et al.* (2009).

N, P and K removal by weeds

Among the weed management practices, lowest NPK removal were recorded with combination of pendimethalin @ 1.0 kg/ha fb quizalofop-p-ethyl@ 50 g a.i./ha at 20 DAS over pendimethalin @ 1.0 kg/ha at harvest stage during both the years of experimentation. However, NPK removal was recorded higher under weedy check (Table 8). The nutrient uptake is resultant of dry matter production of weeds and

Table 6 Effect of herbicides and integrated nutrient management on weed dry weight (g)/m at different stages of French bean

| Treatments | 30 DAS | | 60 DAS | | 90 DAS | | At harvest | |
|---|--------------|--------------|--------------|--------------|----------------|----------------|----------------|----------------|
| | 2009-10 | 2010-11 | 2009-10 | 2010-11 | 2009-10 | 2010-11 | 2009-10 | 2010-11 |
| <i>Herbicide application</i> | | | | | | | | |
| W1 - Quizalofop-p-ethyl 50g/ha at 20 DAS | 2.37 (5.11) | 2.25 (4.55)* | 6.38 (40.16) | 6.19 (37.82) | 7.50 (55.82) | 7.38 (54.05) | 7.37 (53.80) | 7.31 (53.05) |
| W2 - Pendimethalin 1.0 kg/ha | 2.17 (4.21) | 2.11 (3.94) | 5.25 (27.11) | 5.09 (25.46) | 7.31 (52.96) | 7.19 (51.30) | 7.14 (50.57) | 7.08 (49.66) |
| W3- Pendimethalin 1.0 kg/ha fb Quizalofop- p- ethyl@ 50 g a.i./ha at 20 DAS | 2.02 (3.58) | 1.98 (3.41) | 4.58 (20.68) | 4.51 (19.90) | 6.98 (48.20) | 6.86 (46.53) | 6.79 (45.62) | 6.72 (44.68) |
| W4 - Weedy check | 3.37 (10.87) | 3.10 (9.14) | 6.91 (47.33) | 6.75 (45.17) | 12.93 (166.82) | 12.85 (164.69) | 12.85 (164.62) | 12.78 (162.85) |
| W5 - 2 HW (20+40 DAS) | 0.89 (0.29) | 0.83 (0.19) | 4.01 (15.61) | 4.00 (15.49) | 6.08 (36.60) | 5.95 (34.97) | 5.72 (32.27) | 5.64 (31.42) |
| SEm ± | 0.02 | 0.01 | 0.10 | 0.04 | 0.08 | 0.11 | 0.08 | 0.09 |
| CD (P = 0.05) | 0.05 | 0.02 | 0.34 | 0.12 | 0.24 | 0.36 | 0.25 | 0.28 |
| <i>Fertilizer level</i> | | | | | | | | |
| F1 - RD (N120 P60 K40 S20) | 2.22 (5.13) | 2.09 (4.40) | 5.70 (33.43) | 5.51 (31.19) | 8.28 (74.45) | 8.16 (72.62) | 8.10 (71.88) | 8.03 (70.74) |
| F2 – RD+200 kg/ha Wellgro soil (dust) | 2.14 (4.71) | 2.03 (4.14) | 5.33 (29.11) | 5.25 (28.04) | 8.10 (70.94) | 7.99 (69.20) | 7.89 (67.90) | 7.85 (67.17) |
| F3 - RD + 300 kg/ha Wellgro soil (dust) | 2.10 (4.52) | 2.01 (4.05) | 5.28 (28.52) | 5.21 (27.69) | 8.03 (69.56) | 7.92 (67.81) | 7.85 (66.99) | 7.79 (66.07) |
| F4 - 75% RD + 200 kg/ha Wellgro soil (dust) | 2.18 (4.89) | 2.08 (4.32) | 5.43 (30.14) | 5.31 (28.65) | 8.23 (73.41) | 8.11 (71.64) | 8.05 (70.88) | 7.97 (69.62) |
| F5 - 75% RD + 300 kg/ha Wellgro soil (dust) | 2.17 (4.81) | 2.05 (4.23) | 5.39 (29.69) | 5.27 (28.27) | 8.16 (72.03) | 8.05 (70.27) | 7.97 (69.26) | 7.90 (68.02) |
| SEm ± | 0.01 | 0.01 | 0.04 | 0.03 | 0.02 | 0.05 | 0.03 | 0.03 |
| CD (P = 0.05) | 0.03 | 0.02 | 0.11 | 0.08 | 0.07 | 0.14 | 0.07 | 0.08 |

*Figures in parentheses are the original values

Table 7 Effect of herbicides and integrated nutrient management on weed control efficiency and weed index of French bean

| Treatments | Weed control efficiency | | Weed Index | | Grain yield (kg/ha) | |
|---|-------------------------|---------|------------|---------|---------------------|---------|
| | 2009-10 | 2010-11 | 2009-10 | 2010-11 | 2009-10 | 2010-11 |
| <i>Herbicide application</i> | | | | | | |
| W ₁ - Quizalofop-p-ethyl 50 g/ha at 20 DAS | 67.31 | 67.41 | 34.20 | 29.25 | 1314 | 1468 |
| W ₂ - Pendimethalin 1.0 kg/ha | 69.26 | 69.47 | 20.43 | 19.33 | 1589 | 1674 |
| W ₃ - Pendimethalin 1.0 kg/ha fb quizalofop-p-ethyl 50 g/ha at 20 DAS | 72.25 | 72.54 | 7.46 | 5.54 | 1848 | 1960 |
| W ₄ - Weedy check | 0.00 | 0.00 | 52.48 | 50.51 | 949 | 1027 |
| W ₅ - 2 HW (20+40 DAS) | 80.38 | 80.68 | 0.00 | 0.00 | 1997 | 2075 |
| SEm± | | | | | 24.75 | 26.21 |
| CD (P=0.05) | | | | | 80.69 | 85.43 |
| <i>Fertilizer level</i> | | | | | | |
| F ₁ - RD (N ₁₂₀ P ₆₀ K ₄₀ S ₂₀) | 58.35 | 58.51 | 16.87 | 13.46 | 1424 | 1549 |
| F ₂ – RD +200 kg/ha Wellgro soil (dust) | 57.69 | 57.88 | 0.00 | 0.00 | 1713 | 1790 |
| F ₃ – RD + 300 kg/ha Wellgro soil (dust) | 57.27 | 57.42 | 3.07 | 2.91 | 1662 | 1738 |
| F ₄ - 75% RD + 200 kg/ha Wellgro soil (dust) | 58.23 | 58.44 | 18.79 | 12.85 | 1442 | 1560 |
| F ₅ - 75% RD + 300 kg/ha Wellgro soil (dust) | 57.65 | 57.86 | 17.65 | 12.51 | 1456 | 1566 |
| SEm± | | | | | 18.20 | 18.96 |
| CD (P=0.05) | | | | | 52.06 | 54.22 |

Table 8 Nitrogen, phosphorus and potassium (N, P and K) removal by weeds at harvest as influenced by herbicide and fertilizer level

| Treatment | NPK removal by weeds at harvest | | | | | |
|--|---------------------------------|---------------|-------------------|---------------|-------------------|----------------|
| | N-removal (kg/ha) | | P-removal (kg/ha) | | K-removal (kg/ha) | |
| | 2009 | 2010 | 2009 | 2010 | 2009 | 2010 |
| <i>Herbicide application</i> | | | | | | |
| W1 - Quizalofop-p-ethyl 50 g/ha at 20 DAS | 5.50 (29.878) | 5.29 (27.648) | 2.200 (4.338)* | 2.180 (4.261) | 2.798 (7.331) | 2.559 (6.049) |
| W2- Pendimethalin 1.0 kg/ha | 4.94 (23.971) | 4.71 (21.741) | 1.841 (2.890) | 1.771 (2.641) | 2.286 (4.725) | 1.988 (3.454) |
| W3 - Pendimethalin 1.0 kg/ha fb quizalofop-p-ethyl 50 g/ha at 20 DAS | 4.35 (18.427) | 4.08 (16.197) | 1.563 (1.967) | 1.495 (1.755) | 1.959 (3.338) | 1.607 (2.081) |
| W4 - Weedy check | 6.51 (41.906) | 6.34 (39.676) | 2.508 (5.805) | 2.398 (5.257) | 3.739 (13.477) | 3.567 (12.221) |
| W5 - 2 HW (20+40 DAS) | 3.38 (11.468) | 2.98 (9.288) | 1.222 (0.994) | 0.911 (0.334) | 1.848 (2.916) | 1.473 (1.670) |
| SEm± | 0.07 | 0.07 | 0.016 | 0.014 | 0.002 | 0.001 |
| CD (P=0.05) | 0.23 | 0.24 | 0.051 | 0.045 | 0.008 | 0.002 |
| <i>Fertilizer level</i> | | | | | | |
| F1 - RD (N120 P60 K40 S20) | 5.24 (28.029) | 5.02 (25.799) | 1.919 (3.407) | 1.825 (3.106) | 2.541 (6.431) | 2.256 (5.163) |
| F2 – RD + 200 kg/ha Wellgro soil (dust) | 4.87 (24.057) | 4.62 (21.827) | 1.853 (3.111) | 1.726 (2.751) | 2.518 (6.319) | 2.230 (5.060) |
| F3 – RD + 300 kg/ha Wellgro soil (dust) | 4.50 (21.993) | 4.18 (19.763) | 1.786 (2.943) | 1.654 (2.545) | 2.512 (6.293) | 2.219 (5.081) |
| F4 - 75% RD + 200 kg/ha Wellgro soil (dust) | 5.07 (29.197) | 4.83 (23.967) | 1.912 (3.382) | 1.800 (3.025) | 2.533 (6.390) | 2.248 (5.132) |
| F5 - 75% RD+ 300 kg/ha Wellgro soil (dust) | 4.99 (25.372) | 4.75 (23.142) | 1.864 (3.151) | 1.751 (2.819) | 2.526 (6.356) | 2.241 (5.102) |
| SEm± | 0.05 | 0.05 | 0.011 | 0.013 | 0.002 | 0.001 |
| CD (P=0.05) | 0.13 | 0.14 | 0.030 | 0.038 | 0.007 | 0.002 |

*Figures in parentheses are the original values

weed management responsible for low weed dry matter and minimum N, P and K removal.

Data revealed that NPK removal by weeds was also significantly lower under RD + 300 kg/ha Wellgro soil (dust) and showed its superiority over rest of the treatments during both the years of study except recommended dose + 200 kg/ha Wellgro soil (dust) where it was at par with each other. Thereafter, 75% R recommended dose + 300 kg/ha Wellgro soil (dust) and 75% recommended dose +200 kg/ha Wellgro soil (dust) removed at par with each other, but significantly superior to recommended dose of fertilizers with respect to nutrient removal. These results are corroborated with the findings of Mishra *et al.* (1993).

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